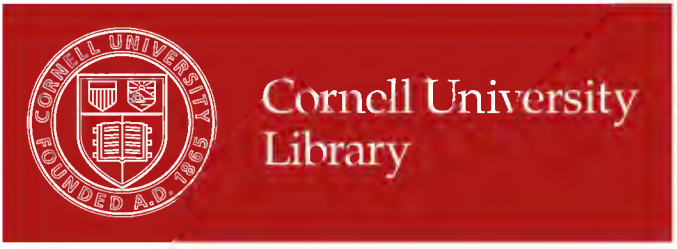

# SURGICAL EMERGENCIES

## *12 LECTURES*

DELIVERED AT THE UNIVERSITY OF LEIPSIC

BY

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PRIVAT DOCENT OF SURGERY

*TRANSLATED AND REVISED*

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# CONTENTS.

## LECTURE VI.



## LECTURE VII.



## LECTURE VIII.

## LECTURE IX.



## LECTURE X.

## LECTURE XI.



## LECTURE XI.—*Continued.*



## LECTURE XII.

# EDITOR'S PREFACE.

THE work herewith presented to the English speaking medical public occupies a unique position, and therefore needs no apology. It treats of subjects that have been left untouched by the few short and imperfect works on surgical emergencies that have appeared, and which, in general treatises on the surgical art, are so encumbered by the mass of other matter that they are inaccessible. Not a small portion of the book is devoted to subjects which can scarcely be classed as surgical emergencies, but which may be included in the term "Life-saving Operations." These matters are extremely important to the practitioner who has not the time to wade through ponderous tomes and innumerable journals, and they are dealt with in a precise, sententious and masterly manner. Many of them are so recent in their origin, that they have not as yet even been incorporated in the text-books. Thanks are due to Dr. Ferd. C. Valentine of this city, for his invaluable assistance in the preparation of the manuscript.

FREDERICK A. LYONS.

244 WEST FORTY-NINTH ST., NEW YORK.

# PREFACE.

I AM induced to publish the following course of lectures by the great interest evinced by my hearers in the subject treated of.

I am perfectly conscious of the imperfections of this little work. Besides, I have lacked the requisite leisure to put the finishing touches to every detail, as I should have liked. But who has succeeded, in this busy bustling decade, in writing a book at once so interesting and weighty as Diefenbach's "Operative Surgery," or so deeply instructive as Virchow's "Cellular Pathology," or so inspiring as Billroth's "General Surgical Pathology," appeared to us in the years of our academic life?

Above all things, I have striven to be true: not to say more nor less than was necessary to the elucidation of the subject.

The clinical preceptor, who has followed without prejudice the progress of surgical science, and whose ambition is not to be satisfied by the brilliant success of his operations alone, will find but little that is new in this book. On the other hand, I hope the young practitioner will gladly take it up for advice, when he leaves the student's life for independent activity in his profession, and suddenly becomes conscious of the great responsibility which he has taken upon himself. For to this day, as formerly, even to the most industrious of young physicians, and even at our best universities, that practical training and that confidence are lacking, which are alone obtainable within hospitals. Most of them have seen much, learned much, but experienced little.

But even the physician, who has had the privilege of enlarging his knowledge by daily hospital practice, may be

stimulated by the present volume to ponder over his own observations.

As regards citations, only those works have been noticed which have been a source of instruction to myself or which excel by their impartial presentation of the literature of the subject. I therefore hope not to offend any one, nor call forth touchy questions of priority. I dedicate this small volume to Bernhard von Langenbeck and Carl Ludwig, to whom I am indebted for the best I have learned. To them belongs the credit for all that is good and useful within these pages.

L. VON LESSER.

Leipsic.

# SURGICAL EMERGENCIES.

## LECTURE I.

*Reasons for a special treatise on the subject.—Considerations for the division of the methods of aid in emergencies.—The assistance to be rendered either to a single individual or to a number.—Accidents to numbers both in times of war and peace.*

GENTLEMEN: The separate discussion of surgical aid in cases of pressing danger to life is not included in theoretical lectures on Surgery. Its aim is a direct completion of our clinical instruction.

Conditions which are directly life-endangering are but seldom seen at the clinic; for it would depend upon chance that such cases should present themselves for aid just during the hours of instruction. Should this even be the case, the symptoms of the dangerous condition and the means of assistance appear in an altogether too favorable light, simply because at the clinic the most favorable circumstances imaginable obtain as to the place of operation, professional experience, and intelligent assistance.

The same cases will appear to you entirely different in your own practice. You will often be called upon to exercise your profession when life is in peril, within narrow, badly lighted rooms, surrounded by despairing relatives, panic-stricken friends, and distrustful old women.

In such cases, only the firmest principles and technical surety will give you that measure of self-confidence which forthwith commands respect from both the patient and those surrounding him, but which also preserves from inexcusable passivity as well as from irresponsible officiousness (delirium operatorum). Secondly, surgical aid in

sudden emergencies needs a separate discussion, because the course of instruction differs materially from that in a clinic. In the latter only selected cases are laid before the student. Not only their history, but also the special individuality of the patient is circumstantially considered, in addition to an exhaustive investigation of the disease.

In emergencies where the patient's life is in imminent danger, or even where he is unconscious, and those around him are unfit for thought or action, unmanned by the suddenness of the misfortune, then it falls upon you to recognize at once the chief symptom and to take promptly the right measures to combat it. Even within the walls of the hospital the urgency of the need scarcely permits a more minute demonstration of the separate phases of the disease.

It is exactly for this reason that we feel justified in leaving for the present the sick-bed for the experiment-table at the clinic, for the study of life-endangering conditions. We certainly concur in the protest against simply transferring the results of experiments upon animals to phases of disease in man; we would specially recall to you the results of vaccine-tuberculosis as compared with the progress of human phthisis. *For conditions dangerous to life, however, experiments upon animals serve excellently well, as prototypes of disturbed life functions.* At the experiment-table we are enabled to study much more precisely the separate phases of a disturbance without regard to the subsequent preservation of the individual's life. It is in my opinion exactly through this peculiarity in the method of instruction that surgical aid in sudden emergencies possesses an advantage over the other applications of surgery.

But you will not only meet such emergencies rarely in the clinic, and not only does the course of instruction appear different, but also emergencies occupy a distinct technical position among surgical operations. As remarked above, the latter are performed at the clinic in a specially chosen operating-room, amidst the best possible conditions of light, ventilation and temperature. Here it is possible to get ready all necessary instruments, to procure new ones, or even to have such constructed as best serve the special case.

But when we meet in our every-day practice, unexpectedly and unequipped, conditions endangering life, then we are often called upon to improvise the necessary instruments, to accomplish much with imperfect materials, and in

spite o tne scantiness of our means to approach as near as possible the strict requirements of the art of operating, and particularly that of dressing, of the present day.

The surgeon's talent for improvising will be particularly challenged by the accidents of war. It is true this talent is a natural gift, but its development and cultivation must not be left to the moment of necessity—it must be schooled and exercised beforehand. Modern military surgery has learned to appreciate sufficiently the importance of this fact.

The surgeon's aid in emergency differs according to its being rendered either to a single individual or to a greater number of people.

Of course the consideration of the aid to be rendered to a single individual will form the basis of our remarks on its application to a number of people. The exact appreciation of its essential principles will facilitate the establishment of those rules which are to guide us in cases of accidents befalling larger numbers of people, and where it is of chief import to select correctly the right kind of aid according to its urgency, consequently to divide labor most effectively and where the surgeon's activity in organizing outweighs for the moment that of operating.

Mortal dangers befalling single individuals may be chiefly classified as follows;

A. Cases of loss of vital elements (blood).

B. Cases of obstruction to the regular reproduction of the same (air, nourishment).

C. Cases in which the accumulation of material endangers either mechanically, or chemically, or simultaneously in both ways the constituent parts of individual organs or the entire organism (ascites, empyæma, emphysema diffusum, urinary retention, quickly growing tumors, abscesses or blood-infiltrations, poisoning by gases, such as carbonic oxide, carbonic acid, hydrosulphurous acid and chloroform, or by fluids, such as opium, morphine, septic substances, etc.).

The above classification corresponds also to the contents of the main chapters, and the surgical manipulations to be treated of therein, viz.:

I. Hæmostasis. II. Air-supply in cases of suffocation and poisoning. III. Laryngotomy and gastrotomy, treatment of constriction of the intestines, *atresia ani et defectus ani*, and the formation of artificial anus. IV. Treatment of the accumulation of fluids in the pleura, peritoneum, bladder, uterus, etc. V. Treatment of quickly growing cystic

and solid tumors (oviarian cysts, echinococci, struma, solid abdominal tumors).

For aid in emergencies, in accidents to numbers, we shall use as a type, the aid in military cases, both on the battle-field and in the first halting-places, with due regard to the rules of dressing for transport, and for means of transport to the rear.

The difference of accidents in factories, mines, buildings, water-works, on railroads, etc., compared with casualties of war, consists in the fact that in the latter we have to deal mainly with a quite particular form of injury.

In contrast with gunshot wounds of the bones and of the viscera, as they almost exclusively characterize modern warfare, the calamities of peace bring before us in various numbers injuries by explosion, burns, bruises and contusions.

As regards the technique of operations I shall confine myself to an exact presentation only of the most useful method and to the enumeration of those instruments only which are absolutely necessary to a hasty operation, because, as I emphasized above, we must learn to perform our task with the least amount of extraneous aid.

You will see, gentlemen, that the territory which we are jointly to traverse is very extensive. We must guard against losing sight of the general principles in the examination of the details: we must endeavor to bring into prominence the essential points of our inquiry. Thus I hope you will become equipped with a sufficient amount of principles to be applied in cases of need, in which you will have the difficult task of appearing as saviour. The words of Hamlet: "'Tis all in being ready," are applicable to no other branch of medical activity better than to ours.

## LECTURE II.

*Loss of vital elements.—Losses of blood.—On the amount of blood present in the organism and on the vascular extent.—Experimental increase of the amount of blood.—On the parts where the infused blood collects.—The extensiveness of the capacity of the vascular system.—The bleeding to death of plethoric persons.—On the destiny of the infused blood.—On cases of bleeding to death.—The course of the blood-pressure curves in those cases.—Slow and quick bleeding to death.—Qualitative changes of blood-mixture in phlebotomy.*

GENTLEMEN: Hæmostasis is one of the most important chapters of surgery. The experience of the operator is best evinced by his certainty on this subject. The great number of methods and means of hæmostasis, which already exist, and which continually increase, are the best proof of the difficulties which must often be overcome.

Before entering upon the theme proper it is our duty to form an exact conception of the vascular system, and of the distribution of blood therein.

You see here two dogs. I have provided the carotid of the larger and the jugular vein of the smaller with canulæ. By a glass tubing I unite both canulæ, and after expulsion of the contained air, I cause—by a proceeding to be explained in Lecture VI.—the blood of the carotid of the larger animal to pass over into the jugular vein of the smaller one. The latter remains perfectly quiet, breathing only less often, and not so deeply. After a short time the larger animal, losing its blood, becomes restless—its restlessness increases, and at last it falls into general convulsions—it has bled to faintness. We finish our transfusion of blood, and leave the recipient of it alone for the present, who, being freed, runs off gaily, and at the most is troubled for a short time after the operation merely by tenesmus.

But in the animal which has been bled to exhaustion, we see that the blood comes but drop by drop from the pulseless, almost empty carotid. The animal moans, breathes deep and heavy, grows gradually weaker, and is in an appar-

ently unconscious state. Now we place the feet of the animal higher than its head, and we squeeze out its extremities several times in a centripetal direction, and bring a vigorous pressure to bear upon its belly and thorax. And we notice that the respiration becomes stronger, likewise the pulse, and the blood commences to flow more copiously from the canula in the carotid, so that we might yet obtain a considerable amount of blood. But if we had closed the carotid before, the animal would visibly recover and could be kept alive in spite of the great loss of blood and its life-endangering symptoms.

Let us now return to the recipient of the blood. He weighed before the transfusion 4625 kilo. after the transfusion 5050 kilo. consequently his own (hypothetical) amount of blood of 32,375 grams (7 per cent of the weight of his body, was increased by 425 grams. He therefore possessed after the transfusion a blood amount of 748.75 grams, or 14.8 per cent of the weight of his body in blood.

According to this the loser of the blood had weighed before the transfusion 8.85 kilo., after the transfusion 8.37 kilo. He had therefore suffered a loss of blood of 480 grams (Experiment of Nov. 6, 1878). In another experiment (May 8, 1878,) the recipient of the blood weighed before the transfusion 3.75 kilo., after the transfusion 3.91 kilo. The increase of blood to its own original amount of 262.5 (calculated at 7 per cent) amounted to 160 grams. The animal consequently possessed after the transfusion 422.5 grams, or 10.8 per cent of the weight of the body in blood. The loser the blood weighed 4.43 kilograms before the transfusion, 4.21 kilo. after death, by the squeezing of the legs, the belly and the thorax, 50 grams more of blood could be obtained from the apparently bloodless animal. Entire loss of blood equals 220 grams or 4.9 per cent of the weight of the body in blood.

The interesting fact that the entire amount of blood increases to a high degree; that it may even be doubled and trebled without endangering the vitality of the organism, forces the question upon us, *in what parts can this so copiously infused blood find room.*

At first we might imagine that the vascular system has been ruptured somewhere, and that the superfluity of blood has emptied itself as such into the tissues, or that such at least has been the case with the watery elements of the blood. Here the results of dissection of animals overfilled

with blood are of importance. They show that in the regular course of transfusion there are nowhere any blood extravasations, nor œdematous places. Nor does the amount of lymph, which during the transfusion appears in an increased quantity from the opened thoracic duct accord with a corresponding proportional decrease of blood-pressure. In a like manner we notice, by a comparison of the coloring power of the blood before and after the transfusion, only a small discharge of plasma.

Worm-Müller * and I † have effectually shown that the copiously transfused blood remains within the vascular system. And this result is obtained from a comparison of the blood pressure. Thus, Worm-Müller was enabled to set up *three territories for the capacity of the vascular system.*

In the *first* territory the blood-pressure rises to its normal height, when an anæmic organism, which possesses about 1.5 to 2.5 per cent of the body-weight less blood than normally, is re-supplied with the missing fraction of its normal blood quantity. In the *second* territory there is an abnormal increase of blood of 2.4 per cent of the body-weight. Here the blood-pressure is now increased beyond the usual limit, now it sinks below it. That these conditions depend on vaso-motor influences, is proven by the absence of these variations, in cases where the transfusion was performed in animals with a severed spinal cord.

The third territory possesses a special interest, because in spite of the twofold or threefold increase of the quantity of blood, its pressure remains invariably at the normal height, and can in no manner be increased. This proves that not a simple adaptation of the vascular system but a continuous enlargement of it took place. A comparison of the blood-pressure curves, when plethoric animals are bled to death, furnishes the best support for this.

For if we decrease in a normal individual the quantity of blood to about one half, the pressure will fall to a life-menacing depth. The same may be obtained without any loss of blood, by discontinuing the influence of the vaso-motor centres on the muscular structure of the vessels by means

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* Worm-Müller, Die Abhängigkeit des arteriellen Druckes von der Blutmenge. Berichte der königl, sächs. Gesellschaft der Wissenschaften. Math-phys. Classe. Sitzung vom 12 Dec., 1875.

† L. v. Lesser, Ueber die Anpassungder Gefässe an grosse Blutmengen. Daselbst, Sitzung vom 8 August, 1874.

of severing the spinal cord. By doing this we do not decrease the vascular contents, but increase the vascular capacity.

What, then, of plethoric individuals? It is true, in bleeding to death they yield more blood than normal individuals.

A lively dog, 2.39 kilo. in weight, was subjected (Experiment Nov. 6, 1879,) to a transfusion of blood from the carotid of a larger animal. He thereupon weighed 2.54 kilo., consequently an increase in blood of 150 gr. A week afterwards he weighed 2.414 kilo. At being bled to death he yielded 184 gr. of blood, while in proportion to his ultimate body-weight he should have yielded but 120.7 gr.

On the other hand, in smaller losses of blood, the pressure falls much more quickly to a life-menacing depth. Indeed, this may occur when the animals possess not only their original amount of blood, but even an additional part of infused blood. They are, in spite if it, in the same danger as normal individuals, whose blood amount may have been decreased below the usual quantity.

*Plethoric individuals, particularly with hyperæmia, are consequently by reason of the enlargement of their vascular space more susceptible to loss of blood than normal organisms.*

But the other question arises, whether in plethora the entire vascular system or only single parts of it are subject to enlargement.

That the entire accumulation of blood does not take place within the great arterial avenues is best supported by the relative immutability of the blood-pressure. Nor does the infused blood gather within the large veins. This we see, in the first instance, by dissection. Nor are we able to increase the bloodpressure or the phlebomtomic quantity, of animals, bled after a copious infusion of blood, by squeezing out of the veins. To no greater extent is the blood-pressure influenced by division of the vagus nerve as the number of beats of the heart is thereby increased, we would also expect that a greater quantity of blood would be forced within the same unit of time into the arterial systen if much blood had accumulated within the veins. Moreover the direct measurement of the tension of the crural veins during hyperæmia shows only temporary, not permanent increase. We have to reduce these changes of increase to an accumulation within the veins. But they are also noticeable in other parts, as the visible effect of blood-transfusion, in the face, the conjunctiva, the mucous membranes. Within the

confines of the portal circulation we may also have, at a brusque infusion of blood, particularly into the jugular veins, a direct plethora by its passage through the liver. The tenesmus (which now and then appear after transfusion) and even hæmorrhage from the intestines are attributable to this same cause. Experiments have even shown that in quick injections the liver is lacerated and ruptured.*

There remains the last possibility: *that the excess of blood accumulates principally in the small vessels.* And this is supported by several facts.

We know that the blood capacity of the individual organs varies. Here psychic, sensorial and sensible reflexes, are as much to be considered direct mechanical influences, according to the position of the parts, in existing or absent muscle-contractions, etc. Particularly instructive in this respect are the changing redness and pallor of the skin, then the changes of volumes of the extremities under different influences, as they are demonstrated by the ingenious contrivance of Mosso† (plethysmograph) and then particularly the arrangement of the corpora spongiosa.

There are consequently within the organism a great number of minor vessels at disposal, within which the moderately infused blood may disseminate itself. Only in case of an immoderate infusion of blood, Worm-Müller's third territory of vascular capacity, a rupture of the vascular walls, would come into question.

The division of blood will differ in the individual organs according to their capacity. Thus we have before us within the cutis, within the muscular vessels, the bone vessels, in all mucous membranes, particularly in the intestine, but also in the liver and spleen, those parts in which blood-infusions make a hyperæmia first visible, corresponding to the normally considerable blood-capacity. That this is so, you have already learned from the experiment, where we succeeded by the *squeezing* of the extremities, the pressure of belly and thorax, not only in increasing the blood-pressure, but also the quantity of the blood from the carotid. But you notice at the same time that the blood accumulates to a con-

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* Casse. De la Transfusion du sang. Mémoire présenté à l'Académie royale de médecine à Bruxelles, le 29 Novembre, 1873, p. 55.

† Mosso, Sopra un nuovo metodo per scrivere i movimenti dei vasi sanguigni nell' uomo. Torino, 1875. (cf. Centralblatt für Chirurgie, 1876. S. 166).

siderable extent also within the vessels which are on one hand not directly subject to the action of the heart, on the other hand inaccessible as well to our manipulations (blood vessels of the bones, and of the spinal cord).

What now becomes of the infused blood? Does the organism permanently retain the increased serum and discs of the blood? Only at first. For soon the increased secretion of urine and urea reduces the quantity of blood and the number of blood-corpuscule to their normal limit. If we infuse not heterogeneous but homogenous blood, so that no direct dissolution of the corpuscles takes place, both the blood serum and the urine are without hæmoglobine. And the homogeneous but superfluous blood-discs perish within the blood-mass, as happens continually with decrepit discs at other times as well.* Thus Valentin's † opinion that the organism always maintains a constant quantity of blood in proportion to the body-weight is also so far true that within the blood-tissue only a definite number of blood-discs can retain a permanent vitality.

Having convinced ourselves, that the division of blood within the individual organs is varying and that this becomes the more apparent in copious infusion, we must enquire, *whether this peculiarity of blood-disposition also prevails with losses of blood.*

Indeed already the course of the blood-pressure curve after phlebotomy offers certain points of support. A sudden opening of a large vascular trunk causes by the rapid depletion of the aortic contents an immediate decrease of blood-pressure, which, however, soon gives way to a proportionately larger increase, caused by the excitement of the vaso-motor centres. This excitement is less pronounced in a slow loss of blood. Here the pressure may keep at the normal height, till about one half of the normal quantity of blood has been withdrawn from the organism. *But after this the blood pressure decreases rapidly to the very lowest point, when death appears after convulsions.* This happens when the individual has lost about 5 per cent. of its body-weight in blood. Only with animals made plethoric, have we noticed death and therefore the corresponding decrease of pressure to the lowest point, while the organism disposes of an

* Worm-Müller, Transfusion und Plethora. Christiania, 1875. Universitätsprogramm. S. 63.

† Valentin, Lehrbuch der Physiol. 1847. Bd. I. S. 413.

amount of blood quite surpassing the normal quantity. More than five per cent of the body-weight in blood can by no means be expected to be drawn. Even in case of tetanization of the spinal cord of animals, no greater phlebotomic quantity can be obtained, because in case of bleeding with suddenly decreasing blood-pressure, a blood distribution in the above mentioned sense takes place in the organism in such a manner that a large quantity of blood within these vessels is not subject to vaso-motor influences.

A further, practically important point is derived from the observation of the blood-pressure curve, according to the slow or rapid progress of the bleeding. Thus we have seen that a rapid blood-depletion causes an increase of blood-pressure instead of a decrease, and would consequently not be justified, where it is our object to produce by blood-depletion a decrease of tension in the aortic system. At any rate, the loss of blood required would be disproportionately great in comparison with the object sought.

The course of the blood-pressure curve teaches us that in slow bleeding the normal tensions of the vascular system may be retained for a long time, till suddenly the life-menacing decrease of the blood-pressure makes its appearance. This insidious course of the blood-pressure conditions in connection with the suddenly approaching catastrophe, is only too often met with at the sick-bed, and is caused either by repeated hæmorrhages after surgical operation or by that apparently insignificant continuous puerperal flowing after confinement. Here we must promptly recognize the danger and remove it before it is too late.

The battle-field furnishes the most important example of the conditions of rapid rise of blood-pressure after loss of blood in gun-shot wounds of the great vascular trunks. The rapidly appearing vascular spasm and single, but copious, hæmorrhage, with subsequent sudden decrease of tension in the aortic system have been known for ages as an attempt of nature towards spontaneous hæmostasis.

The peculiar blood-distribution within the bleeding organism which exhibits so great a similarity with that in blood-injections, constitutes quite frequently the cause of death—and not the loss of blood itself. *The individual does not perish from want of blood, but from want of motion of the blood.**

* Vergl. auch L. v. Lesser, Transfusion und Autotransfusion. Samml. klin. Vorträge. Nr. 86.

But to these quantitative conditions of blood-distribution are joined besides qualitative ones of special significance.

It is an old-established fact that after phlebotomy the blood becomes more watery and poorer in pigment. But for this thinning of the blood, various attempts at explanation have been made.

It was claimed chiefly that blood-loss caused tissue juice and lymph to flow into the blood. Later it was believed, that the loss of red blood-discs directly caused the paleness.

Closer experimental investigation of these questions has shown, that in rapid bleeding neither the entrance of serum nor lymph, nor the loss of blood-discs directly influences the pigmental contents of the different phlebotomic portions. *These pigment-contents exhibit relations which, graphically represented, correspond perfectly to the course of the blood-pressure curve venesections.** The proportion of blood-corpuscles maintains approximately its normal measure, to decrease suddenly after the loss of about one half of the blood in the body. But while the blood-pressure invariably decreases until death, the proportion of pigment may increase far beyond the normal height even after death itself.

Moreover, a number of other experiments where no blood-depletion had taken place, show that the proportion of pigment does not depend directly on the loss of blood, but on blood-pressure conditions. That the peculiar blood-distribution which takes place is accompanied by a corresponding arrangement of red blood-discs, in which a large number of blood-corpuscles are temporarily thrown aside from the blood-current. Particularly remarkable is the fact, that in individuals who remain at rest for a considerable space of time, the proportion of pigment in the blood may at times decrease far below the normal measure, even without any loss of blood, and that sudden and violent muscular motions, as well as the squeezing of the extremities, etc., may increase, again, the proportion of pigment even beyond the normal standard.

Similarly in venesections with decreasing blood-pressure, there will remain a larger number of red blood-discs within the vessels whose blood-column is no longer under the influence of the impulse of the heart.

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* L. v. Lesser, Ueber die Vertheilung der rothen Blutscheiben im Blutstrome. Reichert und du Bois' Archiv, 1878. S. 41—108 in der physiol. Abth.

For the present we shall let it be an open question how far chemical material, which temporarily decreases blood-pressure, may assist in changing the blood-composition. (See below.)

Thus the sum total of the experimental facts hitherto discussed, has shown us, first, that the organism needs a certain quantity of arterial tension, to remain alive; secondly, that this tension depends not so much on the absolute quantity of blood, but rather on the distribution of it; and thirdly that this blood-distribution is closely connected with a peculiar arrangement of the blood-discs.

What practical results may now be derived from these facts for our instruction on the subject of hæmostasis?

## LECTURES III AND IV.

*Hæmostasis. — Blood-saving. — Hæmostasis, especially of blood from injured arteries.—Progress of occurrences during the healing of arterial wounds.—Proliferation of the vascular walls and thrombus organization.—Bruises, cuts and punctures of arteries.—Foreign bodies grazing the arterial tube.—Catgut as material for ligatures and its action within the different tissues.—Thread-ligature in (aseptic) wounds.—Instruments for vascular ligatures.—Ligature of artery stumps and in the continuity of the vessels.—Substitutes for thread-ligature.—Hæmostasis at certain parts of the body.—Places for the compression of arterial trunks.*

Generally there are three means of meeting the loss of blood, occasioned by intentional or unintentional wounds, viz.:

A. The saving of blood; B. The stopping of blood; C. The compensation for loss of blood.

We are indebted to Esmarch * for methodically perfecting the art of blood-saving during operations, even though in former times the method had been repeatedly applied, particularly in amputations, of raising the extremities and squeezing them out before beginning the compression of the supplying arterial trunk.

Aside from the direct economizing of blood, Esmarch's method can claim the following additional advantages:

*a.* If the progress of the wound is not aseptic, the limited loss of blood diminishes the danger of a septic infection, which in the same manner as extended thrombi, occurs easier in anæmic cases than elsewhere.†

*b.* Fresh wounds, as they do not bleed, need not be sponged so frequently during an operation, which considerably lessens irritation; then

* Esmarch, Ueber Blutersparung bei Operationen an den Extremitäten. Verh. d. deutschen Gesellschaft für Chirurgie. II. Congress. (Sitzung vom 18 April, 1873).

† Esmarch, Ueber künstliche Blutleere. Verh. d. deutchen Gesellschaft für Chirurgie. III. Congress. (Grössere Vorträge Nr. 1.)

*c.* The method allows operation without any assistance whatever.

*d.* Its simplicity is such that any layman may soon learn and perform it independently.

*e.* The circumscribed compression of large vascular trunks is avoided, and this may become a matter of importance, where the vascular walls are liable to rupture.

*f.* The method of blood-depletion is pre-eminently applicable for the production of local anæsthesia, by combining ischæmia with a congelation of the parts, either by an ether-spray or by the aid of a frigorific mixture, and the like, Thus we are enabled to perform painlessly, even without general narcosis, certain operations, as, for instance, that of an ingrown nail,* the incision of panaritiæ, even amputation and resection of *phalangæ.*

*g.* The method of blood-depletion of the parts allows us furthermore to apply more effectively the actual, or galvano-cautery, than formerly, for the intensity and extent of the cauterization is much easier adjusted, if the field of operation is not continually moistened by the rush of blood.

*h.* This method obtains a special importance in operations, where it is necessary to subject the affected parts to a quick and close examination, as in synovitis tuberculosa and tumefactions, in order to remove as thoroughly as possible the affected tissue.

*i.* Likewise are we enabled by this artificial ischæmia to find easily and remove any extraneous body, particularly needles.

*k.* This proceeding proves itself important for the detection of injured or severed arteries. It enables us also to proceed more courageously, in the extirpation of aneurisms, than we could formerly. The proposition came from England that this method should be also applied in the direct treatment of aneurisms, and it has been used there several times with excellent results.

*l.* Finally, this method will be met with in the subject of blood-substitution as a very prompt means of autotransfusion.

To carry out the method Esmarch proposed a rubber bandage of a certain length and breadth for binding the extremities, and a thick rubber tube for circular constric-

* Girard, Zur Erleichterung der Localanästhesie. Centralblatt für Chirurgie. 1874. Nr. 2.

tion of the extremities above the rubber bandage. The rubber bandage must be so applied that we first unroll an extra portion which is to hang out, before the bandaging either of hands or toes commences, and that we draw the bandage only so tight that it evenly envelopes the extremity, and at the same time lightly compresses it, without exerting on any one place a stronger local pressure. It has been recommended to use instead of the rubber tube, which by too tight pulling may easily act injuriously, pieces of strong woven rubber bands with clamps or hooks. It seems simplest to wind around the last piece of the band in several turns over one another, for the purpose of constriction, and to fasten these twists securely and permanently by a clamp that may be screwed together and pushed under. It is only for the shoulder and hip joints that this contrivance for constriction is fastened somewhat differently. For the shoulder joint we formerly made a recumbent figure of 8, crossing the two parts of the tube, on top of the shoulder, while the ends were tied in the armpit of the opposite side. The hindrance to respiration makes it desirable to change this arrangement; we therefore let our assistant hold down with the palm of his hand the two parts of the tube at the point of intersection on top of the shoulder and to prevent its slipping we fasten a strip either across the chest or the back, which pulls in the direction of the other armpit.

A hip constriction of the upper thigh can only be obtained by guiding the tube around the root of the leg from the rear, crossing the two parts in front above the femoral artery, *i.e.*, the centre of Poupart's ligament, and twisting the ends around the pelvis, tying them again in front. In order to obtain an energetic compression it is advisable to insert below the crossing point of the two parts, above the Ligamentum Poupartii, a roll or bandage.

In operations in the locality of the hip-joint itself, particularly for the exarticulation of the upper thigh, this method of blood-depletion does not prove sufficient. Here the direct compression of the aorta claims its right. This is most frequently made in the direction from the abdomen (of course after thorough depletion of the intestines) by aid of the hands, or, better yet, by aid of spinal compressors (Esmarch, III. Chir. Congress. II. Page 7). But sometimes it may be made in the direction from the rectum, perhaps best after its forced dilatation and insertion of the whole hand.

The chief objection to the use of rubber bands for wrapping after Esmarch's method is the perishableness of the material; particularly does this objection hold good for war purposes. It has therefore been proposed to substitute a well-woven linen bandage for the rubber band (Bardeleben) and to use instead of the constriction-tube simply as heretofore a gag-tourniquet without pelotte, such as is found in every military surgeon's case.*

Among other results of Esmarch's method we have the constriction of an extremity of the sound side of a body, to dam up the blood there, while an operation is performed on the other leg. If the loss of blood should have been too copious that accumulated in the sound leg is furnished to the heart by loosening the constriction and raising the extremity (Bell†). Any elastic band (a pair of suspenders) may serve as a constriction-tube in case of need.

Another disadvantage of Esmarch's method is the paralysis of the vascular walls within the extremity excluded from blood circulation for a length of time. The bleeding which occurs after loosening the constriction may be so copious as to outweigh completely the amount of blood saved during the operation. It is, therefore, principally important to close before loosening the constriction all vascular openings and to clasp all yet bleeding points with catch-forceps, of which a great number must be in readiness. Where we need not expect a bleeding from larger vessels, as in sequestrotomy or in scraping out an articular cavity, etc., the antiseptic dressing may be put on, and tight at that, before loosening the constriction. But we must carefully watch it; change it immediately if blood penetrates it, at any rate after twenty-four hours. The advice is also important, to let the compression of the supplying arterial trunk continue a considerable length of time after detachment of the tube. The second proposition lately made by König ‡ is to keep the extremity raised not only during the application of the dressing, but also a considerable time after the operation. Among the other means of reducing the loss of blood to the lowest

* Köhler, Die blutsparende Methode im Felde. Deutsche Militärärztl. Zeitschrif, 1877. Heft 8 u. 9. S. 371–381.

† Bell, Note on a mode of saving blood in great operations. (Edinb. *Med. Journal*, 1877. Vol. 2, p. 141.)

‡ König, Ueber die Vortheile der Verbindung der verticalen Suspension mit dem Esmarch's chen Verfahren zum Zwecke der Erzielung blutloser Operation. Centralblatt für Chirurgie, 1879. S. 537.

quantity, after Esmarch's constriction, we may mention the tampon with antiseptic (hot) sponges and the application of the electric current.

I. Stopping bleeding from (A) arteries.

As a type of the occurrences taking place in injuries to arteries, the spontaneous stopping of blood may serve us, which sometimes (tearing off of an extremity by a piece of bombshell) may be observed even in very large trunks.

We have to consider here, first, the lacerated and ragged condition of the vascular tissues, then the elastic retraction of the severed vascular tube, and finally the blood coagulation, *i.e.*, thrombus formation, within the injured portion of the artery. In the historical development of the search for means of hæmostasis from arteries, greater importance has now been given to thrombus formation, and then again to the direct fibrination and agglutination of the vascular walls. In connection with this we find, also, now one kind of therapeutic propositions, now another, principally recommended and applied.

In winding a thread about an artery-tube, the primary stoppage of blood is caused by the tearing of the interior and central vessel coats which roll up inwardly. At the place of ligature, more powerfully toward the centre than the periphery, a blood-coagulation gradually occurs, the place of which is after awhile taken by a cicatrix, which coalesces with the proliferation of the connective tissue proceeding from the severed vascular tube, and prevents the exit of the blood-wave.

The so-called organization of the thrombus was ascribed by some to the penetration of cells from the blood into the thrombus.* Others maintained that at the closing of the vascular tube the thrombus lost all importance, and laid the chief stress on the proliferation of the cells of the intima endothelium and the consequent displacement of the vascular lumen. † To-day we know, principally from the experiments of Senftleben ‡ that the organization of the thrombus does not proceed from the blood, but that the latter is per-

* C. O. Weber, Handb. der Chir. von Pitha und Billroth, 1865. Bd. I. 1. Abth. S. 139 u. f.

† Baumgarten, Die sog. Organization des Thrombus. Leipzig, 1877, und Raab, Ueber die Entwicklung der Narbe im Blutgefäss nach der Unterbindung. Arch f. klin. Chir Bd. XXIII. Heft 2. S. 156.

‡ Senftleben, Ueber den Verschluss der Blutgefässe nach der Unterbindung. Virchow's Archiv, 1879. Bd. 77.

meated by cells, which penetrate from the vasa vasorum through the vascular walls into the thrombus, become fixed there as cells of the newly formed young connective tissue, while the substance of the thrombus itself becomes subject to resorption. At the same time with this, direct agglutination of the intima-fold doubtless occurs, as we have learned by the experiments of Baumgarten and Raab.

These healing processes of injured arteries undergo certain modifications according to the nature of the injury. Bruises and contusions of an artery correspond nearest with the nature of a ligature. Thus we saw, for instance, when extremities were crushed or torn off by heavy shots, how very frequently a spontaneous blood-stoppage of even large vessel-trunks, as that of the subclavian or femoral artery, occurred.

In punctured wounds, which decrease in frequency in war, but increase among certain classes of people, in peace, a parietal thrombus arises primarily at the place of injury, subsequently out of this a cicatrix of connective tissue, which, gradually yielding to the blood-wave, causes the formation of an aneurismal dilatation of the vascular tube, or if the puncture affects besides the artery the contiguous vein as well, or *vice versa*, both the arterial and the venous wound may agglutinate. The arterial blood flows over directly into the vein amidst the varicose enlargement of the peripheral venous net. Thus arises the *varix aneurysmaticus*, as it has often been observed after phlebotomy in the bend of the elbow with accompanying injury of the arteria brachialis.

We shall speak below more exhaustively on punctures which penetrate the arterial tube, and hence injure it in two spots.

Different conditions obtain with sabre-wounds. If these are made obliquely in one part of the arterial tube, the diagonal slit will be drawn asunder by the elastic fibres, at work in the longitudinal axis of the tube, into a roundish opening, where the obliquely arranged orbicularis muscles are unable to cause either a peripheral or a central constriction of the arterial opening. In such cases we must complete the diagonal separation and ligate the two ends of the vascular tube. Where, for instance, a ball in its track grazed an artery, without directly injuring the vascular wall, it is best to put a ligature as soon as possible on both sides of the grazed point. For mortification and desquamation of the grazed

wall may subsequently take place with fatal secondary hæmorrhage. These considerations also lead us to remove as soon as possible all extraneous bodies, in cases where balls lie in proximity to vascular tubes, or where bone splinters with sharp edges pierce the vascular wall. Similar measures are requisite in complicated fractures, where a large vascular trunk is threatened by bone splinters, and here as well, we must give preference to primary ligature at the injured spot, to the less safe ligature in continuity in case of secondary hæmorrhage.

So we see that in all arterial injuries *the safest means against primary and secondary hæmorrhages consists in ligature if possible on both sides of the injured spot of the vascular wall.* And this principle is entitled to the greatest consideration; indeed we may say that it has obtained an unshakable, universal validity since the introduction of the antiseptic treatment of wounds, and since we have obtained an almost ideal material for ligature in the carbolized catgut. In comparison with this, the questions whether the blood stoppage is due to thrombus or to the proliferation of the vascular wall, lose their significance, as the catgut does not sever the arterial tube, but furnishes a cicatricial ring at the spot of ligation, which thickens the vascular wall.

Lister* himself has first shown how the carbolized catgut heals in, as it were. He thought that it changed into a ring of living tissue. Several subsequent investigators have confirmed Lister's statements, but have not been able to establish that the catgut continues to exist at the place of ligation after a shorter or longer period of time. The assumption that the lifeless gut should be changed into a living ring of tissue also causes a certain confusion.

Though it was to be expected that in the aseptic progress of the wound the catgut ligature after healing into the tissue, could not act otherwise than blood extravasations subject to resorption, dead bone splinters, etc., under similar conditions of wound-healing, yet it was of importance to establish by experiments, how long the catgut remains as such within the tissue and in what way its transformation into stable connective tissue comes about. As we often meet difficulties in completing the antiseptic treatment of wounds with vascular ligatures in animals, I preferred to

* Lister, Observations on ligature of arteries on the antiseptic system. (*The Lancet*, 1869. April 3.)

demonstrate the action of catgut within the different tissues and organs in another way, namely, by *complete subcutaneous puncture, the skin having been slided to one side.** I inserted pieces of catgut under the skin of rabbits on different parts of the body, other pieces I introduced by means of a silver needle obliquely through the thorax, and in different directions through the abdominal cavity, and was thus enabled to let the catgut remain within the different tissues any length of time I pleased. The result was: (1) That the catgut is to be recognized as such much longer than was usually supposed. (2) That the gut becomes subject to resorption quickest on those spots where it is exposed to pressure or traction.

(3) That an immigration of cells into the catgut takes place, proceeding from the periphery. These cells, which, at first singly, then in radial groups, penetrate the inner parts of the catgut, crumble it, and gradually bring about a substitution of it by young connective tissue, which in time metamorphoses into a cicatricial mass nearly resembling the original catgut in shape and appearance. With all this, it once happened that the catgut was traceable as such without much change of texture on the 61st day after its subcutaneous insertion. In other cases we found it thoroughly permeated by cells after 32 and 36 days, or even changed into a cylindrical mass of young connective tissue. But even on the 95th day after insertion the then cicatricial mass was plainly distinguishable from its surroundings. Similar results were obtained with certain modifications by insertion of the catgut into the belly of muscles and into joints, by subperiosteal entwining of bones, by lacing of the trachea with catgut. A similar appearance was presented by pieces of catgut, which by puncture of the abdominal cavity or the thoracic space, had been deposited either in the lungs or the myocardium, the liver, the kidneys, or near the intestine or the bladder. In these cases it was noticeable that on the edge, where the catgut freely penetrated into the intestinal lumen or the vesical cavity, it appeared looser, more lacerable, the channel of the puncture likewise eroded, which perfectly corresponds to the appearance of the channels of skin puncture by the use of catgut for sutures.

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* L. v. Lesser, Ueber das Verhalten des Catgut im Organismus und über Heteroplastik. Druckfertiges Manuscript.

The dissolution of the catgut takes place more rapidly when the progress is not purely aseptic; quickest in places where unmistakable decomposition exists, as, for instance, in those experiments where catgut had been inserted into festering channels or fistulæ.* Here catgut acts as every other dead organic matter, as mortified sinew scraps, muscle portions or necrotic connective tissue. Therefore no conclusions can be arrived at from these or similar experiments for the adaptability of catgut for ligatures. But where we are able to cause the catgut to heal in taking antiseptic cautions in the above-described manner, it offers for surgical technique results hitherto unattained.

Furthermore, where the ligature thread lay in the wound as an extraneous body, saturated with wound-secretions, and had to be expelled after separation of the vascular wall, dangers of various kinds to the progress of the wound had to be considered—primary hæmorrhages when the ligature was severed too quickly, secondary hæmorrhages when the wound suppurated on the fifth or sixth day after operation, when the fluid, saturating the ligature thread, decomposed and communicating the decomposition to the vascular wall, caused an erosion of the latter and a disintegration of the thrombus. But the danger of a wound-decomposition was increased in proportion to the quantity of ligature material accumulated in the wound. Hence the endeavor to have as few ligations of a wound as possible; hence an incomplete blood-stoppage and in consequence of this the frequent direct secondary hæmorrhages. Another result of the above-mentioned calamities was numerous propositions to create substitutes for ligature, and these propositions furnished an unpleasant picture of bickerings and petty-mindedness, and which propositions were as a rule really more crude, injurious, and more complicated than the thread-ligature itself.

But even in the further stages of the wound progress a new danger arose on account of the slowness of expulsion of the thread, namely, the so-called ulterior secondary hæmorrhages. These were caused either by the fact that the thread had cut through the vascular lumen deeper on one side than on others (arterial fistules), or by the incompleteness of the thrombus formation, when the thread had

* P. Bruns, Die temporäre Ligatur der Arterien u. s. f. Deutsche Zeitschr. f. Chir. 1875. Bd. V. S. 69 (des Sep.-Abdr.)

been wound around too closely beneath a large lateral branch. Hence the rule to place the ligature always above a large lateral branch. But this very rule proves itself almost illusory in several very important places of ligation on account of the large number of radiating lateral branches (arteria subclavia.) This rule proved unsuitable to a still higher degree in injuries to a vascular trunk in any part of its course, than it was for the theory of ligature in continuity. In those cases it often became necessary to expose the vessel beyond the starting-point of the next higher lateral branch, and this made the procedure cause much injury. As now the catgut does not cut through the vascular trunk, but, so to speak, forms around it at the place of ligature a strengthening ring, it is immaterial, where the arterial wound is and at what place we place the catgut around the artery.

But catgut has also certain faults, to judge by the above-mentioned results of our experiments as well as by practical experiences. It cannot fulfill its task where it is exposed to too powerful a pressure and traction, or where there is too rapid disintegration of the catgut, as, for instance, within the abdominal cavity. (This happens here, compared with other places, probably on account of the abnormally large quantity of fluid and the frequently imperfect aseptic progress of the wound.) Catgut seems for the above reasons also unsuitable for relaxation sutures on the skin surface in plastic operations, for muscle-sutures (suture of the abdominal after laparotomy) for uterus-suture after hysterotomy and for pedicle-ligature after ovariotomy. Here we are compelled to use substitutes, such as silver-thread for use on the skin surface, or for sutures and ligatures below the surface, silk of various thicknesses, which has been previously boiled in a five-per-cent solution of carbolic acid and kept there for some time (Czerny*).

It only remains now to mention the ligature material formerly in use or still applicable. Thus sea-weed, being a substance which causes very little irritation, has proved serviceable, particularly for sutures. Also horse-hair, thoroughly cleansed and delubricated has been proven to cause but little irritation. Lately braids of prepared horse-

* Czerny, Studien zur Radicalbehandlung der Hernien. Wiener med. Wochensshrift, 1877. Nr. 21–24.

hair have even been used by Lister as capillary drains instead of rubber tubes for the same purpose. We shall keep this great applicability of horse-hair in view with reference particularly to military surgery.

Besides raw Chinese silk, recommended by Astley Cooper and Simon, which we now exclusively prepare after Czerny's method, Spencer Wells has found thick hemp-threads particularly suitable for ligature of the ovarian pedicle. Common thread, saturated with carbolic acid, may also be used in case of need. In rare cases use is made of English silkworm-gut on account of its resistency and its incapacity for imbibition, which is used on English fishing tackle for suspending the hook.

For the introduction of silver among metal threads, we are indebted to Marion Sims (1857), who first used it in an original manner for relaxation sutures. Two years later Simpson tried to introduce iron ; while we mention Diffenbach's lead-threads for staphyloraphy only as of historical interest.

To apply a ligature to an injured or completely bisected, or even intact, artery, we need, besides the material, only a very slight apparatus. We shall need a sharp-pointed hollow scalpel, where the tissues must be cut through as far as the vessel. Where the injured vessel lies deep in the passage of a ball or between splinters of a complicated fracture, we shall need a hernia-knife for dilatation of the skin and muscle wound and for the inclovation of fascial fissures, in order to lay the injured artery bare with accuracy, and to be able to examine it in all directions, and to cut out eventually the injured part of the vessel. (Rose's * bloodless extirpation of arterial punctures). A free-hand cut reaching the subcutaneous connective tissue must be made to sever the uninjured skin, after having determined the exact position of the artery to be exposed. The edges of the cut must be smooth and the skin must be incised in its entire thickness from point to point of the wound. The incision of the lower strata, the fasciæ, the perimysia and even of the vascular sheaths must be made in the following manner: By the aid of two hooked forceps, of which the operator holds one with his left hand, while the assistant holds the other, we raise the layer, in which the incision is

* Rose, Ueber Stichwunden der Oberschenkelgefässe und ihre sicherste Behandlung. Sammlung klinischer Vorträge. Nr. 92.

to be made, in a fold, occupying an oblique direction to the cut, and carefully make the incision. Thus the injury of the vessels is the least, the hæmorrhage reduced to its minimum, an injury of the larger vessels impossible, which, in former operations with the director very frequently happened. We regret the use of the director, because it yields exactly the reverse of the advantages derived from incision between two pairs of forceps.

Having reached the vascular sheath we open it carefully to a short extent, isolate the vascular tube within its sheath by blunt hooks which are curved either at the edge (Cooper, Gräfe) or on the surface (Lang, Rust). Deschamps' needle, bent at right angles, also belongs here. These so-called *artery hooks* have an eye at the point, guiding the thread which is to be wound around the arterial tube. But such a hook can be easily improvised out of any pliable probe with an eye or out of a strong curved sewing-needle, whose sharp point is held by a ligature forceps; and, indeed, in emergencies, when the necessary instruments are lacking, we might even use our finger for pressing apart the soft parts and isolating the vascular tube. Vessels completely severed are seized with special artery forceps. These differ from each other by the shape of their branches, which take hold, and by their manner of locking. The forceps with movable lock (Schmucker, Fricke, Amussat) cannot be recommended as highly, on account of the difficulty of cleaning them, as those with a spring lock and with bulging blades, which terminate conically. The bulging shape is therefore preferable, because it is impossible to tie up the ends of the forceps with the loop of thread meant for the ligature. But such tying up happens all the easier, the deeper the artery lies which we wish to grasp with our forceps. This was the reason why they formerly constructed special forceps for deep ligature (Luer, Mathieu). Our object is easiest obtained by seizing the artery-stump with two forceps near each other. It is impossible to tie up the points of two forceps. (Hamilton's bull dog forceps are by far the best form to use.) Formerly they also used for seizing and pulling out vessels sharp curved hooks, (Fabricius Hildanus, Bromfield; Sextor's hooks with point-covers);

The ligature of the ends of completely severed vessels happens most frequently;

(1) With amputation stumps as Ambroise Paré (1509–1590)

is said to have applied extensively during his campaign under King Francis I.

(2) With wounds, viz.:

*a.* Operation-wounds.

*b.* Wounds within complicated bone-fractures.

The already mentioned artery-punctures deserve special mention. There danger lies in their frequent and apparently enigmatical secondary hæmorrhages.

With these we can least of all rely on a simple compress bandage. *It is necessary to proceed from the very outset thoroughly and radically* to prevent the injuries by the steadily re-occurring losses of blood, which are followed by a life-endangering exhaustion. The patient being chloroformed, we dilate to the required extent the channel of the puncture in the soft parts—and withal as deep as possible, close to the injured blood-vessel, from which a powerful blood-wave rushes forth, continually inundating the entire cavity of the wound. Here we must be quick. The operator forthwith inserts his right index into the wound to find by the touch of his finger-tip the opening of the artery and to stop it up. Now the bleeding ceases. After removal of every thrombus we continue to open the soft parts farther around the index, till the vessel above and below the point of injury may be fully isolated. Now the assistant winds, centrally and peripherally, from the obturating fingertip, a thread around the vascular tube. One would think the hæmostasis would be definite and yet such need not be the case. It may be that between the two ligatures at the wall opposite to the puncture a vascular arm branches off, out of which a secondary hemorrhage may issue at the restitution of the collateral circulation.

That, indeed, the restoration of the collateral circulation takes place very rapidly, even in large vessels, such as the femoral, is beautifully shown by the experiments of Sonnenberg and Tiegel,* who were able to observe in the ligation of the aorta a considerable rise of pressure but a short time after the ligation, by means of the manometer, which had been attached to the femoral both centrally and peripherally. Similar observations in man were made by Neudörfer & Kocher.†

* Sonnenberg und Tiegel, Einige Bemerkungen betreffend die Herstellung des Collateralkreislaufes u. s. f. Centralblatt f. Chir. 1876. Nr. 44. S. 689.

† Kocher, Beitrag zur Unterbindung der Art. fem. comm. v. Langenb. Archiv, 1869. Bd. XI. S. 537.

Or the puncturing instrument, which has entered obliquely to the longitudinal axis of the artery, has touched not only the front wall of the vessel but also the hind wall, but much higher either upward or downward, so that the puncture occupies a position either above the central or beneath the peripheral ligature. Here as well secondary hæmorrhage may occur with the same degree of danger as if nothing had been done by the surgeon. Therefore Rose's proposition, to isolate the arterial puncture totally, to bind all affluent vessels separately and extirpate them after securing the arterial tube centrally and peripherally, is worthy of the highest consideration.

The ligature of arteries in continuity is applied—1. in the treatment of aneurisms (after Antyllus, Hunter, Brasdor and Wardrop), also in the extirpation of aneurisms.

2. As a preparatory act for greater operations to avoid considerable losses of blood, either in case of difficulties having arisen in the timely securing of large vessels, or in case of extirpation of tumors of very large size and containing a large amount of blood. Ligation of the lingualis before tongue extirpation—ligation of the subclavian in large mammal tumors with high infiltration of the axillary glands—ligation of the axillary in exarticulation of the shoulder on account of large swelling of the head of the humerus, ligation of the femoral in exarticulation of the thigh.

3. In bleeding from artery wounds, as central ligature; formerly, however, recommended unjustifiably often. The most striking proof of the uncertainty of the procedure is furnished by the history of many cases, in which several ligatures, approaching closer and closer the heart have proved fruitless. Particularly since we have been enabled by Esmarch's method to empty the parts of blood and to have an unimpeded and plain view of the injured vessels within them, we can set up the general and incontrovertible principle that *in all artery wounds the sovereign means of hæmostasis consists in antiseptic thread-ligature at the very point of injury.*

If in spite of this, we devote a few remarks to substitutes for the ligature, we do so, because the kind and manner of hæmostasis is determined in certain cases by the topographical conditions of the bleeding part. Again, a few of the methods about to be mentioned have acquired a lasting citizenship in operative technique, so that we cannot pass them by in silence.

We divide the substitutes for ligature into provisory, *i.e.*, such as are to prevent the loss of blood till a ligature performs this function; and permanent, *i.e.*, such as have been recommended and introduced to avoid the application of ligature.

Among the (*a*) *provisory* substitutes we have chiefly *compression* and first of all its simplest and most important form, viz.,

1. *Digital compression.* This is used,

*a.* Either directly in the wound, by closing the channels of shot or puncture-wounds with the finger, as we have seen already (arterial punctures), or we press several fingers of one hand upon the bleeding spot in the pharynx, on the tonsils (after tonsillotomy) or on the hard gum upon the place of exit of the arteria palatina desc. (in uranoplasty). In default of a resisting base, as for instance, in bleeding tonsils, the palm of one hand must be laid under the corner of the jaw to produce a counter-pressure. In cases of bleeding of the arteria palatina desc. it has been proposed to drive in small wooden plugs.

*b.* Or we may compress the surroundings of the wound, already existing or about to be made, in operations on hare-lips, when the assistant presses together with his thumb and index the upper lip in the region of the corner of the mouth, so that on cutting the lip-gap the child loses as little blood as possible.

*c.* We exert a compression indirectly upon the trunk of the supplying artery. This should be the first thing in all hæmorrhages, where we cannot reach its source immediately (continuous digital compression of the supplying artery-trunk has also proved valuable in the treatment of aneurisms), then in amputations, as adjunct to Esmarch's bandage, before and after its completion, or where the presence of suppurating cavities prevents the continuous bandaging as far as the point of constriction. Here we raise the extremity, compress the supplying arterial trunk and wind the bandage only as far as the inflammatory infiltrated region, or that which contains the suppurating cavities and then we add constriction above that region.

It is very important, gentlemen, that you use every opportunity of making yourselves familiar with the exact position of the points for pressure of the great arterial trunks.

You compress the arteria maxillaris ext. against the

margin of the lower jaw near the front edge of the masseter muscle. To compress the carotid you must always stand behind the patient, lay your thumb on his neck and exert a pressure with the three middle fingers of your hand in the furrow between the larynx and the sterno-cleido mastoid in the direction of the spine and as much as possible in the direction of the central line of the spine; thereby you will avoid the simultaneous and painful compression of the vagus nerve. For the compression of the subclavian the patient must lie horizontally or with the upper part of his body raised; you stand at his head and press the artery towards his first rib with your thumb in his fossa supraclavicularis. There is another fact you must remember in case of a sudden hæmorrhage from the arteria axillaris, namely, the possibility of completely interrupting the radial pulse, in pressing the arteria subclavia between the middle part of the clavicle and the first rib, by pressing the shoulder of the patient heavily down and hindwardly. In order to interrupt the pulsation of the arteria brachialis, you either clasp from the outerside of the arm the biceps lump from above or the triceps lump from below, so that your thumb is on the outward side of the upper arm, while the other fingers press the artery in the sulcus bicipit. intern. in the direction of the shaft of the humerus, avoiding the n. median nerve.

The point of compression for the arteria radialis is, by reason of its superficial position, easily found by any one, "there where the pulse is felt." Much more difficult, in spite of its superficial position, is the precise compression of the arteria femoralis under Poupart's ligament. The spot is easily found, if we remember that the artey crosses, in its course, the ligament exactly in the middle. We need therefore only to divide the distance between the spina ant. sup. of the ilium, and the symphysis into two equal parts, mark the centre point with some coloring matter, in order to be able to find the artery at any moment without failure, and to press it tightly against the horizontal ramus of the os pubis. Never omit to mark with ink or colored pencil the position of the femoralis, when in impending hæmorrhages its rapid compression falls to other hands than yours. Hæmorrhages from the art. femoralis, even of very short duration, have frequently resulted in death. We have already spoken of the compression of the aorta from the direction of the rectum.

2. The compression can be made with suitable *instruments*. Either with such which, as the finger, touch the vessel alone; these are the *compressors:* or, the vessel is compressed either together with its surroundings or by them. This idea suggested the original construction of tourniquets. Among the compressors the simplest and directest imitation of the pressing finger is Ehrlich's crutch for the subclavian, which may be improvised out of any strong key, the crest of which is wrapped in cotton.

A compressor for the aorta we have already mentioned in in connection with the elastic bandage. A similar one, named after Dupuytren-Colombat, consists of a cushion for the lumbar-vertebral column, of a semi-circular metal arch, which, at correspondent distance, bends over the abdomen, and of an adjustable pelotte, which is to press the epigastric aorta perpendicularly towards the vertebral column. On the same pattern is constructed the aortic compressor which Tiemann manufactured for the American army.* Similar to these is Bulley's double-compressor, which, in popliteal aneurisms, is to compress the arteria femoralis in its extent from Poupart's ligament to the middle of the upper thigh, alternately on two spots.

Among the tourniquets, the *twist-tourniquet* is the oldest and the most primitive. Hans von Gerstorff (Schylhaus) describes it in his Text-Book of Surgery in the beginning of the sixteenth century. Others maintain that Morel used the *twist-instrument* first during the siege of Besançon (1674). At any rate, the twist-tourniquet deserves, on account of its simplicity, and because it may be easiest improvised, the preference over all others, provided the pressure is accurately calculated. This is particularly applicable to military surgery, which must not be deprived of the tourniquet. The introduction of Esmarch's rubber bandage for temporary hæmostasis on the battle-field is generally impracticable, because rubber soon loses its utility, as observed above, under the influence of changing temperature. The proposition of Bardeleben is, therefore, more practical, viz., to use for Esmarch's bandage on the battle-field, instead of rubber bands, firmly woven linen bandages; to raise, before putting them on, the respective part of the body, and to moisten

* A report on amputations at the hip-joint in military surgery. Circular 7, p. 81, of the War Department. Surgeon-General's Office, U. S. A. 1867.

them slowly after the bandaging from the periphery towards the center. Instead of the rubber tube and the constriction bandage, a twist-tourniquet without pelotte is fastened on with like result (Köhler, *l. c.*)

Approaching the twist-tourniquet is that proposed by Assalini (1812), the *buckle*-tourniquet; more complicated and easier disarranged is the *screw*-tourniquet of J. L. Petit, which has enjoyed, from the beginning of the eighteenth century, great popularity, and of which many modifications exist.

As it is only a matter of historical interest, we shall be as brief as possible in our mention of the permanent substitutes for ligature, since we posess in catgut and carbolized silk, in carrying out the antiseptic method, indeed the simplest and most perfect means of effectually closing arteries.

The oldest, so to speak, the prototype of our modern method of ligation, is the *mass-ligature*, just as Paré applied it. Roser lately recommended it, justly, as a *method of circumsuture* for those cases where we are not able to look for or isolate the bleeding vessels.

In a wider sense the *percutaneous circumsuture* belongs here, which was proposed by Middeldorp for hæmorrhages from the palmar arch, where compressing threads are conducted through the entire thickness of the fleshy parts of the hand, between the bones.

The second substitute for simple thread-ligature, the so-called *temporary ligature*, has an interesting history of development, as it is a sequence to the numerous experiments with animals, made by Jones, Travers, Scarpa, B. U. Walther *et al.*, in regard to the mechanism of complete arterial hæmostasis. The different methods of *temporary arterial ligature and temporary arterial closure* were founded on the observation that an arterial tube, which has been ligated, bruised, or even only compressed for a few days, becomes permanently impervious to the flow of blood; and suggested by the consideration of the former disadvantages and dangers of the simple thread-ligature, which was only dissolved by the complete severance of the artery.

In order to be able to remove the thread at the desired time, after a temporary arterial ligature, little pieces of cork were inserted between the thread and the artery (Cline, Forster), or little wooden plates (Desault), or little rolls of sticking-plaster (Rous), or linen (Scarpa's cylinder-

ligature), or peculiar ligature knots were made, which were easily loosened by pulling the ends of the thread, ("*reef-knot*," of Churchill, Mattei's loop à la Ricord, Ogston's simple knot with bow). Finally, threads and loops of metal wire were used, which were drawn through particular little arterial tubes, or ligature-tubes, stretched tightly, and subsequently cut through and pulled out of the wound. (Delpech, Walther, V. Bruns, Peters, Van Gieson, N. P. Smith, Baltimore, Prichard.) The last named used horsehair.

For arterial closure we find particular compressors used, of which, to the present day, there exist about two dozen different forms. (Literature, see P. Bruns: "Temporary Ligature of Arteries," *l. c.*) According to the principles, which came into consideration in applying the above mentioned compressors, special names have been chosen for the different modifications of arterial closure, (Vanzetti's Uncipressure, Verneuil's Forcipressure, Péan's "Pincement des Vaisseaux," etc.) The next space in this arrangement is best occupied by the torsion of arterial stumps (Amussat's torsio arteriarum), which is always useful for small vessels, and has even been found by several surgeons reliable for large arterial trunks (Bryant). And finally the acupressure of Simpson, and the acutorsion of Billroth, which were sent forth with so much *éclat*, and are widely used. In the former the injured vessel is pressed with the aid of a long needle, which is drawn through behind it, either against the skin surface, or against the *fleshy* part, or against the bone, according to the position of the vessel in the amputation wound.

Acufilopressure is described (Dix, Keith) as a procedure where the vascular tube is pressed with the aid of a wire loop entwined in the shape of an 8, toward a needle, inserted into the fleshy parts. In acutorsion the vascular tube is also twisted, by means of long needles, around its own longitudinal axis, either around one or two right angles, as the case may be, and closed in this manner.

## LECTURE V.

*Hæmorrhages from veins.—Their frequency, cause, and occurrence.—Phlebitis.—Periphlebitis.—Phleboplastic hæmorrhages of Stromeyer.—Spontaneous hæmostasis.—Vein-ligature.—Substitutes for vein-ligature.—Tamponing in sequestral cavities, in hæmorrhages from the rectum, the vagina, the uterus.—Treatment of hæmorrhages from the nose.—Bellocq's tube.—Bandage-wrapping.—Capillary hæmorrhages.—Search for bleeding point.—Tamponing with bandage-wrapping.—Styptic tampons.—Heat and cold.—Hot douches as safe hæmostatic means.—Glow-heat.—Cautery iron.—Galvano-cauterizer.—Paquelin.—Chemical hæmostatic means.*

Hæmorrhages from venous vessels are more frequent than those from arteries, partly because the former are more numerous and nearer the surface, partly because the thin venous wall is easily torn and crushed by only moderate collision with blunt objects, to which the surface of our body is exposed in ordinary life, while the elastic arterial wall yields to the force exerted upon it.

Besides, in fresh wounds, venous hæmorrhages occur particularly easily where the development of the venous wall is faulty, as in tumors, or where morbid changes have taken place in the venous wall, principally in varicose degenerations. Hæmorrhages from bursting varices, for instance, at the upper thigh, in the trigonum urethræ, in women in the labia majora, often assume a dangerous character and may cause high degrees of anæmia.

The venous hæmorrhages, observed in amputation stumps, have likewise particularly attracted the attention of surgeons. The latest pathologico-anatomical researches in regard to the connection of blood-poisoning and suppuration fever with the so-called inflammation of the veins and their surroundings, (Cruveilhier) had given rise in the minds of investigators to a fear against direct ligature of injured veins. They observed the venous wall, and not without reason, to be particularly susceptible to conveyance of infectious processes, and found in the ligature-loop the im-

mediate cause of the development of phlebitis and periphlebitis.

The spontaneous hæmostasis from veins of small calibre is caused by the tumefaction of the surrounding tissues, which occurs soon after the injury, and arises from the clogging up of the tissue juices. In large vein trunks the hæmorrhage is prevented by the closing of the valves, if they are sufficient for the purpose. Nevertheless, a continuous bleeding may be maintained, if, underneath the valve-lock, a collateral branch continues to empty its blood into the venous stump. An insufficiency of the venous valves, however, occurs, either in a high increase of pressure, in the vein region, which is centrally situated. Thus in uncompensated heart defects, or in a pressure on the vena cava, either by tumefactions or by fluid accumulations within the abdominal cavity. This is especially the case in amputation of the lower extremities; or the valves are changed by the processes of decomposition which take place within the veins, at times even partly destroyed, and in this manner, the thrombus which obstructs the venous lumen likewise becomes subject to disintegration; hæmorrhages occur which have been designated by Stromeyer as phlebostatic, and have been explained by embolia or thrombosis of venous branches of the higher order. If we wish to understand what Stromeyer may have meant by this mode of explanation, we must recall to our mind that the simple closure of individual veins, even of the larger vein-trunks at any particular point in the venous region, on account of the numerous collateral branches, does as yet not produce any disturbance of circulation in the venous system of an extremity.* But that the obstruction of a larger part of a main trunk by a thrombus, which extends in its retrogression into the collateral branches, very soon causes disturbances of the venous blood circulation, the visible sign of which appears in an engorgement œdema. The latter cannot be caused by a ligation of even several venous trunks in an extremity. The infectious periphlebitis, in vein-injuries or vein-ligations without antiseptic cautions, will, however, easily lead to extensive continuous thrombosis within the venous system of, *e.g.*, a leg (phlegmasia alba dolens).

* Sotnitschewsky, Ueber Stauungsädem. Virchow's Archiv f. path, Anat. 1879. Bd. 77.

From what we have seen hitherto, it certainly follows that infectious matter exerts its deleterious influence particularly easily within the course of vein-trunks, upon the entire organism, but that it is transported directly through the thrombus and blood-fluid, or through the net of lymph vessels surrounding the veins. Where we are, therefore, able to prevent the processes of disintegration in wounds, intentional or unintentional, there the direct double ligature of veins assumes its claim as the most reliable means of hæmostasis. Only that the searching for and ligating of all side-branches is necessary in veins to a much higher degree yet than was required in the treatment of arterial punctures.*

Nevertheless, there are cases where we have to forego direct ligation in venous hæmorrhages, be it, that the vascular tube is difficult to seize in its surroundings, as, for instance, in bones, or that the hæmorrhage issues from places which are not directly accessible to the eye and the finger. Here we may endeavor to subdue the hæmorrhage by compression of the vein with the immediate or remote surroundings, and only in the rarest cases by ligation of the supplying arterial main trunk. (Ligation of the arteria femoralis. B. von Langenbeck.)

We have therefore to consider more extensively the *tampon*, with or without bandaging, as a remedy for hæmorrhages from veins.

Sequestral cavities in bones which have been chiseled open we best fill with antiseptic dressing material (Volkman's gauze, or after lining of the bone-cavity with carbolized gauze or preventive taffeta filling with antiseptically prepared jute).

For many cases, particularly where a simultaneous strong influence of wound-secretion or other fluids (from cysts or body-cavities) is to be expected, compression is better made with antiseptic sponges.

The tampon is also used in venous hæmorrhages from the rectum, the vagina, the uterus (in placenta prævia and uterine tumors). After removal of the blood, as far as such is possible, we must use for the tampon numerous balls of antiseptic material wrapped tightly with antiseptic threads, of which several ends must hang loose to enable us to remove

* Rose, Ueber Stichwunden der Oberschenkelgefüsse und ihre sicherste Behandlung. Sammlung klinischer Vorträge. Nr. 92.

the balls by their aid. For bleeding from the rectum, the balls are pressed in, within a glove-shaped piece of gauze linen inserted in the rectum. The balls may be inserted directly into the vagina but always through a speculum to protect the mucous membrane of the vaginal entrance against friction. Perhaps it is preferable to proceed here also, especially if no speculum is at hand, exactly as in tamponing the rectum. If compression of the urethra should hereby occur, the catheter must be used for the removal of the urine. As a substitute for the method just mentioned, we may also use thin rubber balls, which are inflated within the respective channels with air or fluids (kolpeurynter). For hæmorrhages from the rectum we must not forget digital compression, particularly when in narcosis we are able to insert several fingers or the whole hand after previous dilatation of the sphincter ani. For this purpose we insert our two indices hook-shaped into the rectum and draw by jerks the sphincter apart in the sagittal and frontal diameter. Profuse hæmorrhages from the atonic uterus after recent labor have also been successfully stopped by direct compression of the uterus in the direction from the rectum and by counter-pressure from the hypogastrium by the other hand. It scarcely needs mention that all these means only counteract hæmorrhages as such, and not their direct cause, and that in case of their repetition their cause itself must be attacked.

The treatment of nose-bleedings remains to be considered.

If these issue from the outward part of the nose, within the region of the cartilaginous integument, they are easily stopped by outside compression, by pressing the nostrils against the septum. If the bleeding part lies deeper inward between or upon the conchæ or in the vicinity of the choanæ the rinsing of the nostrils with a hot solution of chloride of sodium ($\frac{1}{2}$ per cent.) may be sufficient. In profuse hæmorrhages little can be done with this. Here compression alone is of avail, but not from the outside, for while thereby the flow of blood from the nostrils may be prevented, it makes its way through the choanæ into the pharynx. We first insert a catheter or tube, invented by Bellocq, backward into the nasal cavities, so that the mouth of the catheter or the perforated ball at the top of Bellocq's spring, gliding down in the naso-pharyngeal cavity along the posterior wall of the soft palate, becomes visible in the posterior part of the oral cavity. The loose ends of a

thread are fastened to the top of the catheter or to the perforated metal ball of Bellocq's instrument just described. while the tampon which is to be conveyed upward into the choanæ, is to be crossed by the middle of this thread in the same manner as a bale of cotton is tied with ropes. If we now pull the catheter or Bellocq's tube out of the nose, we drag along the tied up ends of the thread, which is pulled out of the nasal cavity, until the tampon, which is tied to the centre of the thread, has passed the soft palate, reached the choanæ and is pressed within. But the tampon must have a *third* thread, a tail, as it were, which hangs out of the mouth and by which we may at any time pull the tampon back again out of the naso-pharyngeal cavity. The tampon, however, is fastened in the choanæ by tying the ends of the thread which hang from the nostril over a cotton pledget inserted into the latter or over a piece of thick rubber tube, resting against the nostril. If neither a catheter nor one of Bellocq's instruments is at hand, a pliable, smooth stick of wood may be used for the insertion of the threads. (Thomas.*)

For exceptional cases, where no instrument at all is at hand to guide the thread through the nasal into the pharyngeal cavity, by means of which the tampon is to be pulled up into the choanæ, we may try in case the nasal cavity is not entirely stopped up or the patient too weak, the following procedure: we fasten the loop of a double thread in a leaden ball of about the size of a cherry-pit, by opening it first and then pressing it together again. The head of the patient is pulled far back and the ball is dropped into one of the nostrils, while the patient is made to snuffle as hard as possible. By its own weight and the aspiratory current of air the ball penetrates into the naso-pharyngeal space and is forced by the patient's suffocative movements into the anterior parts of the mouth. Now we may fasten the tampon to the loop of the double thread just as above.

The wrapping with bandages, which is of course required for the tamponing of venous hæmorrhages on the surface of the body, may be applied also more independently. The methodic involution of extremities, named after Theden, where the part is bandaged from the periphery toward the centre, has been recommended, in combination with plac-

* Thomas, Traité des opérations d'urgences, Paris 1875.

ing the arm on a splint, after puncture wounds of the brachialis in venesection of the elbow-joint. The bandage is also excellent in hæmorrhages from œdematous or inflammatory infiltrated parts, as well as in hæmorrhages from varices.

Those hæmorrhages where it is difficult to discover the bleeding-point have always been called capillary, or surface hæmorrhages. And yet the discovery will often be possible by great care; and then the application of a ligature will furnish a permanent hæmostasis.

Capillary surface hæmorrhages occur, first, after operations, *e.g.*, after dissolution of adhesions within the abdominal cavity in ovariotomy. Also after extraction of teeth, particularly of the so-called "bleeders" or "hemophiles." Then after leech-bites and from cut-wounds of the skin, as well as after cut-wounds in plastic operations. Likewise considerable hæmorrhages from granulation cells may issue at a pressure upon the large venous trunks of the respiratory regions, *e.g.*, by tumefactions or by a rise of venous tension in uncompensated defects of the heart; consequently under very similar conditions to those under which hæmorrhages from veins occur. Finally, so-called capillary hæmorrhages occur from ulcerated tumors, *e.g.*, hæmorrhoids and disintegrating cancer of breast or uterus.

We have already remarked that we must strive to discover the bleeding-points, even in hæmorrhages of the smallest vessels, and to seize them after isolation. Where the most reliable means fail we have to adopt substitutes, among which the mechanic, the thermically, and chemically acting ones are to be distinguished.

Here, also, as in venous hæmorrhages, the direct tampon, supported by centripetal ligation, claims its place. But the direct compression of the bleeding parts with the finger or a ball of antiseptic dressing material appears the simplest, most suitable precursory hæmostatic during an operation.

In similar manner we stop bleeding in plastic operations, and from obstinately bleeding leech-bites, by suture, acting in the mode of compression. Particularly in plastic operations we would twist only the somewhat larger bleeding trunks.

Further, the tampon may be effected with materials which, aside from compression, are also to act on account of their being saturated with substances which act encrustingly both on the blood and on the vessels. As our object is here

hæmostasis and not disintegration of the vessels, we must always observe the rule, that the styptic balls must be made very small and pressed directly upon the bleeding-point, after it has been thoroughly cleansed of all coagula; otherwise we cause encrustations of the surroundings of the bleeding part, the consequences of which cannot be calculated, and the hæmorrhage may continue after all, as many examples have shown.

As styptic means, we use most commonly fuming nitric acid, then crystallized carbolic acid and chloride of iron. The cauterization with carbolic acid acts at the same time anæsthetically, so that, for painful cauterization, a previous application of carbolic acid has been recommended. Liq. ferri sesqui-chlor. has been found specially effective in hemorrhages from the dental alveoli after tooth-extraction, because the crust which it produces remains. It is to be regretted that it is almost not at all antiseptic, so that frequent rinsing becomes necessary to avoid its very offensive decomposition.

To this day we are not clear as to the application of thermic means, particularly as to the action of cold. Physiological experience teaches that cold retards the coagulation of the blood. Hæmostatically it can therefore not act by way of coagulation, but only by stimulating vascular contraction there, where we have a sufficient circular muscular structure of vessels. The action of fluids, heated far above the temperature of the body, is similar (water, solutions of common salt, chloride of zinc, carbolic acid), only that to the stimulation of vascular contraction is added the other action of heat, long known to physiologists, which consists in enhancing coagulation. The application of the hot douche will therefore stand by us also where vascular contraction is not obtained. It is strange enough that it was the accoucheurs who first called attention to the reliable application of hot solutions (hot douche in uterine hæmorrhages, particularly after miscarriages).

Most text-books on surgery insist with traditional unction on recommending the dripping of icy-cold solutions for stopping capillary hæmorrhages.

I consider it therefore my duty, gentlemen, to call your attention particularly to it, that in surface hæmorrhages, especially in the pharyngeal and nasal cavities, but also from other bony parts of the body, as well as from bone cavities and osteotomic surfaces, after sequestrotomy, after ampu-

tations and resections, you will reach your object of staying the flow of blood much more surely by using for dripping and douching, hot indifferent solutions containing ½ per cent of chloride of sodium, or like antiseptic solutions.

Hæmostasis is also obtained by using the higher and the highest degree of heat for cauterizing. The cautery-iron, in its different shapes (cone, ball, coin-shapes), the porcelain cauterizer of the galvano-caustic apparatus, and the differently-shaped platina-cupolæ of Paquelin's thermo-cauterizer, cauterize, as do styptica, both blood and vessels, and must therefore, like the styptica, only be applied to the bleeding-point. As only certain degrees of heat enhance coagulation, degrees which do not exceed the temperature of the body too much, at any rate, lie below the point at which albumen coagulates, so escharotization is only produced by red-glow heat. White-glow heat chars both vessels and blood. White-hot iron does no longer produce hæmostasis.

The cautery-iron is particularly effective in hæmorrhages from disintegrated vessels, because it simultaneously subdues, often in a striking manner, by stopping the hitherto florid processes of disintegration, and stimulates the formation of healthy young tissue. So in hæmorrhages from granulations, affected by hospital gangrene, in hæmorrhages from suppurating cancers of the mammary gland, the uterus and the rectum.

There are but few *purely chemical* means which are reliable in their action for hæmostasis. We mention first *acidum tannicum*, which is strewn in powder upon the bleeding surface, or which in form of tannin-glycerine pencils, has been recommended particularly for introduction into the uterus cavity. *Argentum nitricum* as a hæmostatic remedy, possesses but weak power: (compare, however, its strong power of vascular contraction in the experiments made by Rosenstein*). But much more frequent is the use of *liquor ferri sequichlor.* in solutions for hæmostatic injections into the rectum and uterus. Let us, finally, mention the oil of turpentine, whose hæmostatic action has been frequently proved. For subcutaneous injections *ergotine* has been used. In this case the extractum secalis cornuti aquos. has been diluted

* Rosenstein Untersuchungen über die örtliche Einwirkung der sogenanten Adstringentia auf die Gefasse. Verhandlungen d. physik. med. Gesellschaft in Würzburg. 1875. Neue Folge IX. Bd. 1—2. Heft.

with equal parts of aqua distillata; of this solution a quantity filling Pravaz's syringe to one quarter or one half, has been hypodermically injected, and simultaneously 10 to 20 drops have been given inwardly every half hour.

Besides ergotine, digitalis and plumbum aceticum deserve special mention, as internal remedies for hæmorrhages, the lungs, for instance.

## LECTURE VI.

BLEEDING.—*Its value as a hæmostatic remedy.—Other indications formerly and at present.—Places for phlebotomy.—Phlebotomy.—Topography of the elbow.—Technique of phlebotomy.—Phlebotomic aneurisms.—Phebotomy on the foot and the neck.—Arteriotomy and its present indications.—Capillary bleeding: Its real value.—Scarification.—Cupping.—Leeches.*

TRANSFUSION.—*Historic periods.—Defibrinated and "intact" blood.—Different methods of transfusion.—Actions of the blood-discs, of the serum and the gaseous contents in the blood of different species of animals.—Significance of fibrin-ferment.—Central arterial blood infusion.—Venous transfusion. —Ingress of air into veins.—Result of experiments.—Blood-injection under the skin and into the abdominal cavity.—Technique of transfusion.—Symptoms in transfusions.—Present Indications.—Territories of anæmia.—Auto-transfusion.*

However paradoxical it may appear to introduce bleeding as a means of hæmostasis, the position it holds as such is nevertheless perfectly clear. The decrease of blood pressure and the diminution of arterial tension are its hæmostatic factors. They may, it is true, be obtained only, as we have seen, by incomparably great losses of blood, which frequently are much larger than the quantity to be economized by hæmostasis.

In former times venesection was resorted to much more frequently, as bleeding was held in high repute, not only as a hæmostatic, but also as an anæsthetic and antiphlogistic remedy.

As an anæsthetic means we find venesection resorted to as early as Galen, at the time of Marcus Aurelius, 130 after Christ, and until chloroform was introduced to produce unconsciousness and facilitate the performance of difficult surgical operations (reduction of dislocation of the femur, reduction of strangulated ruptures, etc.). As antiphlogistic means venesection came into use through the doctrine of crases. And here we find it chiefly used by the French school of Broussais, and then with alarming frequency

consistently carried on in all typhous diseases, even to anæmia (Jugulade). The Vienna school first succeeded (Van Swieten, Skoda) in resisting this senseless waste of blood.

To-day bleeding is pointed out as a remedy in some few cases, aside from those, of course, where the removal of blood which is poisoned or incapable of performing its functions is at issue, or that use of it where the extracted blood is to be injected into a second person.

Thus, bleeding has been recommended:

*a.* In sanguineous apoplexy of the brain. Here its action of decreasing the pressure of the blood is considered as the hæmostatic cause. (See above.)

*b.* Likewise in hyperæmia of the lungs, bleeding has been recommended by Stromeyer, in consonance with the advice of veteran military surgeons, and then not as an antiphlogistic means, but likewise as a hæmostatic one (because it is better to empty the blood by cupping than to let it flow into the thorax. Stromeyer. Maxims of Military Surgery, p. 444.) But here as well the result of bleeding will only then come about when, as observed above, very large quantities of blood have been withdrawn. Therefore it is preferable, in hyperæmia of the lungs, to mitigate the pain and distress of breathing by hypodermic injections of morphine, and to attempt an immobilization of the respective parts of the thorax by position and by bandages. I at least have gained by the latter and by sleep, as the result of morphine, more than by unconsciousness, resulting from copious bleeding, and I have seen others do the same. But after having learned from the results of antiseptic wound treatment that the dangers in opening large body-cavities lie elsewhere than in the mere exposure to air, it will be the task of the future to conceive and try a direct hæmostasis in pulmonary hemorrhages, if possible, under protection of antiseptics, after the affected part of the thorax has been laid open.

Finally, bleeding is recommended

*c.* In pneumonia attended by cyanosis. This is the survival of the old method, when no case of pneumonia escaped bleeding. Bleeding in pneumonia is recommendable with very robust, powerful persons, before the acme of the disease, whereby and by the momentary insufficiency of the right ventricle, blood accumulations arise in the venous system ; but it should never be employed in

pneumonia in the case of drinkers. In this case we must resist the collapse by stimulants, and principally by copious alcoholic doses.

Formerly they used to divide bleedings into three classes: large, at 2 pounds of blood (about 1 litre); medium at 300–350 c.c.m., and small at 200-250 c.c.m. of blood. And bleeding was performed on different venous trunks of the body, as, for instance, at the jugular vein in the middle of the neck, particularly in strangulation. and apoplexy of the brain. Danger was apprehended with this method on account of the possibility of the penetration of air into the heart, of which we shall speak more exhaustively in the subject-matter of Transfusion. Also on the dorsum pedis and the vena saphena magna of the upper thigh. Now, bleeding is performed almost exclusively at the elbow, mostly on the vena mediana basilica. The trunk of the vena basilica on the ulnar side of the arm, and the vena cephalica running on the radial side of the arm, absorb a few superficial and the deep venous branches of the forearm in such a manner that the latter unite to one trunk, and this one in its turn empties its blood through a diagonal tube or through a forked tube partly into the vena cephalica and partly into the vena basilica, almost twice its own size. Consequently the ulnar branch of the venous fork, the vena mediana basilica, is the stronger developed and the more suitable for bleeding, which also appears as the second thicker cord, when the veins of the upper arm are compressed circularly at the figure M of the confluence of veins, which shines through in a bluish color. The vein lies upon the aponeurotic continuation of the biceps tendon, which radiates towards the ulnar side of the arm and is separated by it from the arteria brachialis, which lies underneath, crossing its direction. Above the vein run the branches of the nervus cutaneus brachii medius. The median vein, with its forked branches, is rarely wanting; only at times the vena med. cephalica and the med. basilica run as two separate branches. In case we should not find a suitable vein in the elbow, Lisfranc advises to look for a vena salvatella on the back of the hand or for the vena cephalica, where it runs on the upper arm between the deltoid muscle and the pectoral.

In performing our phlebotomy we must observe the strictest rules of cleanliness. Formerly periphlebitic, and

even pyæmic processes were quite often observed after this apparently innocent operation.

After carefully cleansing the field of operation we lay on a constricting bandage around the centre of the upper arm (phlebotomic bandage, formerly of red color), and close it with a loose and easily-opened knot (fascia ante venæsectionem comprimens). The operator places himself so that he holds the hand of the arm on which the bleeding is to be performed firmly between his hip and his right elbow. The thumb of his left hand presses upon the now copiously filled venous trunk below that part of the elbow on which the vein is to be opened. This is best done with a special knife-blade, protected by a movable covering. This is the phlebotomic lancet which has become so remarkable in the history of many a physician, and which in by-gone times was often the sole symbol of medical knowledge and surgical ability. According to the form of the flat two-edged point they used to distinguish a more thick-bellied and a more slender shape (the phlebotomes of barley-grain and oat-grain shape). With the safety-covers opened upward we seize the lancet close to the point with the thumb and index of our right hand. While now the fourth finger of our operating hand supports itself on the fore arm of the patient, and the third and second fingers are bent in, the point of the phlebotome penetrates into the vein in an oblique direction to the axis of the vascular tube. The oblique direction is chosen to obtain a wider fissure of the vein. On diminishing the pressure of our left thumb the accumulated venous blood rushes in a stream into the measuring vessel held underneath. (Phlebotomic vessel.) If the bleeding is to be interrupted we need only to renew the pressure of our left thumb. The same is to be done at the end of the operation, when the phlebotomic bandage is quickly unwound and a further loss of blood is permanently prevented by an antiseptic compression bandage, which is to take the place of the finger pressure. In time of war we shall often be compelled to content ourselves with an antiseptic ball pressed upon the phlebotomic wound. At any rate, it is advisable to wrap subsequently the entire arm in a bandage, and to secure its quiet position in a sling.

An injury to the arteria brachialis is prevented by using a very sharp lancet, and by inserting its point very slowly into the vein. This injury, and the subsequent formation

of a so-called phlebotomic aneurism, was much more frequent after the substitution of the usual lancet by the spring-lancet, an instrument so unworthy of the hand of a surgeon. (Invention of Paasch, a Dutchman.) An injury to the artery is indicated by the brightened color of the blood-stream, which at times shows pulsations. But a much less deceptive sign is the discontinuance of the bleeding on central compression of the trunk of the arteria brachialis in the centre of the upper arm. Sometimes, when both signs are absent, a swelling is to be noticed in the depth of the phlebotomic wound, when the blood from the artery does not flow outward, but spreads through the vascular layers surrounding the artery.

If there is evidently an injury of the artery, do not waste time in attempting compression, but lay both the artery and vein open and ligate both doubly, according to the rules given for the treatment of arterial punctures. It is only in dubious cases that you can content yourselves with a compressing ligature of the entire arm with subjoined longitudinal pelotte (thick rubber tube), corresponding to the course of the brachialis. The ligatures mentioned by former surgeons: fascia pro venæsectione in cubito and fascia pro aneurysmate are only applicable, together with a total bandaging of the arm.

In phlebotomy, on the dorsum pedis, the bandage was applied above the calf; in that of the vena jugularis the bandage had to be supplied by compression of the bulb of the vein in the trigonum of the sternocleido-mastoid muscle.

The opening of an artery (arteriotomy) to withdraw blood, without intending a subsequent transfusion, is probably at present not made use of. It was recommended formerly on the arteria temporalis in affections of the eye (Wardrop), and it has been risked to puncture the artery like a vein, through the skin, which ought never to be done, just as little as the supplementary application of a simple compression-bandage, even if we were to choose for it a ligature knot (fascia nodosa). If an artery is to be opened, be it for the purpose of making a blood-infusion into its peripheral course, as Hueter once proposed, or with the intention of injecting blood into the artery toward the heart, or, finally, with the object of transfusing the arterial stream directly into a vein of another individual, the arterial vessel must always be carefully isolated and doubly ligated after the transfusion is completed.

Bleeding of smaller vessels, for obtaining blood for transfusion, has been proposed but in isolated instances (Gesellius), while the so-called capillary bleeding was formerly resorted to all the more frequently to remove a supposititious local hyperæmia. The facility of performing the pertinent procedures, together with the importance which the vulgar attributed to local bleeding, explains how these, even more than venous bleeding, became part of the practice of "nurses and barbers," who even to-day in the eyes of the public represent the first resource for surgical aid.

Since our ideas on hyperæmia and blood-distribution in the organism, as you saw in our first lecture, became wholly different from our former ones, the indications for local bleeding had to dwindle down to a minimum. We shall consider its application justifiable only there, or, to speak more correctly, we shall find an indication for local influencing of the conditions of circulation there, where, either by mechanical or inflammatory processes, the local arterial pressure has been diminished, or where a direct obstruction to venous bleeding exists. In both cases we shall have an accumulation of blood in the affected parts, and, as its consequence, either nutrition disturbances or abnormal accumulations of fluids within the tissues. For these cases it will mostly be sufficient to bring about the flow of the blood by opening collateral passages; be it that we produce a collateral reflex vascular paralysis by means of mechanical, thermic, or chemical irritation (hæmospasis, humid heat, so-called derivatives, as cantharides, sinapisms, tincture of iodine). It will be but rarely required to draw the blood directly to the outside, which is, so to speak, temporarily excluded from the circulation, and menaces by its non-circulability the healthy stability of the tissues. And even then we shall reach our end more precisely and in a cleaner manner by correct incision with the knife than by "capillary" bleedings, which were formerly so much in favor, of which we shall speak more exhaustively, and of which we mention scarification, the cupping-glass, and the leech.

Scarification, formerly praised for conjunctivitis-pannosa, hypertrophy of the tonsils, metritis chronica, and acute glossitis, consisted in puncturing the vessels with fine knives. Lately this puncturing has again been resorted to in the treatment of lupus; but there it is claimed that it

causes the shrinking of the vessels, not by blood depletion, which must be as small as possible, but by the accompanying bisection of numerous vessels, which spread to the different tumor-nodes, and by this, resulting obliteration. In acute glossitis, long and deep knife-incisions, parallel with the sagittal lingual axis, which, by the way, are but little painful, often have surprisingly rapid results, particularly for decreasing the swelling of the organ. In hypertrophy of the tonsils, the best remedy, both in the inflammatory stage and after its abatement, consists in excision or resection.

For cupping, an apparatus is required which cuts the main vessels and draws the blood into an attenuated air-space. The so-called English spring-lancet, invented by Lamzweerde at the end of the seventeenth century, answers the first purpose; so do glass or metal, about hemispherical, concave capsules or cups (cupping-glasses, cucurbitæ ventouses). These are heated over an alcohol lamp and pressed, after wetting the edges, to the skin. The cooling of the cup causes an attenuation of the air within, allowing the blood to enter the vacuum of the tightly-adhering cup. Opposed to these so-called wet cups are the dry cups (ventouses sèches), where a previous incision of the skin by the lancet has not been made. Their purpose consists only in producing local hyperæmia of the skin. With this purpose we see them yet often applied to the skin of the thorax in inflammations of the lungs and the pleura. Such hyperæmia on a large scale, and with intended reaction on the entire body, was formerly applied to the leg, including the foot, with the aid of the giant-cup (ventouse monstre) of the so-called Junod's boot.

For hæmospasia, but also for local bleeding in the vicinity of the eye, we use the so-called artificial leech, invented by Heurteloup, in which the skin-wound is produced by a quickly revolving cylindrical concave knife, the blood-suction by a glass syringe, in which the air-attenuation is obtained by raising up the piston, after pressing the syringe close to the skin.

While the cups can only be applied to large flat surfaces, capillary bleeding of small and very uneven places (abdomen, forehead, temples, regio mastoidea and regio suboccipitalis, gums, mouth of the womb, etc.), was effected by the aid of a suction-bowl, constructed on the principle of the dwarf-cup, and that species of leech which has six

brown stripes at the neck (hirudo officinalis). The spot where the leech is to bite must be well cleansed and touched with milk or a sugar solution, or a little puncture of the skin is made with the lancet. To cause the leech to drop off we strew some common salt on the end of his tail. We must use test-tubes to set the leeches to the gum or the mouth of the womb. It is also best to draw a thread through the tail of the leeches, and to watch them closely, so that they do not drop off from the appointed spot and bite at another—the larynx, for instance, as has been observed. The sucking of leeches easily becomes painful, particularly in those territories of the skin which abound in nerves. It is estimated that a leech draws about 8 grams of blood, which, with an after-bleeding of two hours, amounting in all to about 15 grams, is decidedly too low an estimate. The after-bleeding was formerly assisted by the application of warm cataplasms to the wound. In order to increase the activity of the leech they used to cut off his tail, after the example of Münchhausen's horse, cut in two by the closing of the city gate. It is much less cruel, and does not at all interfere with the vitality of the animal, to open the gastric-bags on its two sides, as Beer recommended. (Bdellotomy.)

The leech-bites often continue to bleed undesirably long; it is true, the bleeding may mostly be stopped by continuous compression. But on spots, where such is either impossible or inconvenient, we shall be compelled to resort to a circumsuture-ligature of the leech-bite, or to puncture of the main eminence produced by the suction of the leech, in the centre of which the bite is bleeding. We do this with the aid of a needle, which is drawn through the base of the eminence, around which we then wind a thread, in 8-shaped twists, as was done in the sutura circumvoluta.

The theory of transfusion is difficult of representation. There is scarcely another subject on which we meet with so much fanciful speculation, so much that is unscientific, so much uncritical credulity, and so much carelessness. To search in this haystack for the scientific needle, and to evolve the practically useful principles, shall now be our task.

Even the history of transfusion shows us so indistinct a

Michel Rosa, Lettre fisiologiches Napoli, 1783. Paul Scheel, Die Transfusion und Einspritzung der Arzeneien in die Adern. 2 vols, Copenhagen, 1802 and 1803.

picture of obscure tendencies and ambiguous indications, that the actual history of the development of the doctrine of transfusion begins in fact only with the latest acquisitions to our knowledge of the physiology of the blood.

We best distinguish four larger historical periods.

The oldest, which finds its sources in the description of Greek and Roman poets (Ovid's Metamorphosis, lib. vii.) and starts from the legend of the transfusion of blood with which Medea is said to have rejuvenated the father of Jason. This is the *mythological* period. The second, the *mystic* period, reaches to the 17th century after Christ, and included all the rude attempts to produce by infusion of nutritive and medicinal substances, and also of blood, into the vascular system, certain changes either in the character, or the disposition of the mind of the respective individual. These changes savored only too often of the miraculous.

The third period reaches into the beginning of our present century: it is the *empirical*, excelling by controlling animal experiments, which were undertaken by men in whose science confidence may be placed, and who were universally held in high esteem. In France Denis and Emmerey gave the first impulse to scientific discussion of the question of transfusion; indeed, it was partly due to them that this subject occupied for a long time the scientific minds and learned societies in England as well as in Italy. In England the experiments made by Clarke, Lower, King and Boyle with scientific judgment, deserve special mention, while in Italy Michel Rose made interesting observations on the exchange of blood between different species of animals. He also discovered that large quantities of blood can be injected into the vessels, and that, even if no previous phlebotomy has been made, yet plethora is in no manner observed in the subject of the experiment.

Transfusion soon fell again into disrepute, and indeed from very plain reasons, when they began to use it for all possible chronic and even psychic diseases (as in lyssa humana, cancer, febris putrida). And first through Bischoff,* Prévost and Dumas,† Panum,‡ Brown-Séquard § *et al.*, by

* Bischoff, Müller's Archiv. 1835. Vol. II., page 354.

† Dumas et Geniève T. 17 and Ann. de Chémie. T. 18 p. 294.

‡ Panum, Experimentelle Untersuchungen über Transfusion, etc. Virchow's Archiv. 1863. Bd. 27.

§ Brown Séquard, Comptes rendus de la soc. de biologie, 1849, 1850, 1851, of the Acad. de Sciences, 1851, 1855 and 1857; also, jour. de physiol. T. I.

their partly historic and partly chemical studies on blood, the doctrine of transfusion entered its fourth and scientific period, which we shall briefly call the *modern.*

Here we meet for the first time the important knowledge, that it is the red blood-discs which constitute the important factor of transfusion, and that only arterial or arterialized blood possesses vivifying power.

The utility of defibrinated blood and the greater facility for its injection contributed materially to the popularization of transfusion, and forced the use of the formerly favored animal blood quite into the back-ground. Human defibrinated blood has since received exclusive preference. Thus Blundell * transfused in puerperal hæmorrhage and puerperal fever. Waller † in chronic anæmia, Neudorffer, after prolonged suppuration, in chronic pyæmia, Polli in neuropathies, Dieffenbach‡ in cholera, Blasius§ in leucæmia, Traube‖ and Martin ¶ in carbonic oxide gas poisoning. But as Martin ¶ had successfully employed non-defibrinated human blood, the question was again discussed whether preference should be given to beaten (defibrinated) blood or to not-beaten (complete) blood. Violent disputers urged the loss of vitality of defibrinated blood, and the fear of introducing coagula in its use. Though no scientific proof was offered in support of the above allegations, they were important factors in the resumption of the employment of intact (non-defibrinated) blood. And thus also the recently recommended transfusion of animal's (lamb's) blood was extensively employed. Yet it was soon discarded, because the sanguine expectations which were attached to it, especially in chronic affections (particularly phthisis) were by no means fulfilled.

Previous to formulating our attitude, and designating the

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* Blundell's Vorlesungen über Geburtshilfe, by Thomas Castle, transl. by L. Calman, Leipzig, 1838, complete; also, Cline's Articles in Medico-chirug Transactions. Vol. IX. Part I. 1818.

† Waller, Diss. inaug. med. de sanguinis in periculosa hæmorrhagia uterina transfusione. Erlangen, 1832.

‡ Dieffenbach, Die Transfusion des Plutes, etc. Berlin, 1828, and Die operative Cherurgie, 1845. Bd. I.

§ Blasius, Monatsblatt für med. Statistik Beilage zur deutchen Klinik. 1863.

‖ Friedberg, Die Vergiftung urcdh Kohlendunst. Berlin, 1863. Martin und Barth, Verhandl d. Berlin med. Gesellschaft 1867.

¶ Martin, Ueber die Transfusion bei Blutungen Neuentbundener. Berlin, 1859.

really practical methods, we will briefly recapitulate the procedures which have been proposed and executed.

According to the form in which blood is used, we distinguish:

I. Transfusion of intact (not defibrinated) blood.

1. Conduction into the vein of the recipient directly from the vein of the donor by means of special apparatus (Roussel,* veno-venous transfusion).

2. Conduction of blood obtained by venesection, which is introduced into the recipient's vein by pumping apparatus (Moncocq,† Collin, Mathieu) or syringes (Martin, *l. c.*).

3. Transfusion of capillary blood (obtained by cupping) by means of pumping it into the vein (Gessellius‡).

4. Transference from artery to artery by pumping (Schliep,§ arterio-arterial tranfusion).

5. Direct transfusion from artery to vein. As yet this procedure has been employed only by using the carotid artery of the lamb directly into the human median basilic vein.

II. Transfusion of defibrinated blood (almost exclusively that of man):

1. Into veins,by syringes (Landois,‖ Uterhart,¶ Braune**) or with the use of simple receptacles for measurement) Nagel, Casse).††

2. Into arteries (Hueter's‡‡ periphero-arterial injection of blood.)

We distinguish, according to the donor: A. Transfusion of the blood of the same species (man to man). To this division belong: (*a*) Most of the transfusions with defibrinated blood; (*b*) Veno-venous transfusion of non-defibrinated blood (directly from the vein, or the product of venesection, or capillary blood); (*c*) Arterio-arterial transfusion (Schliep). B. Transfusion of the blood of different species.

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* Roussel, Arch. de l'anat, et de la physiol. 1868, p. 552.

† Moncog, Transfusion instantanée du sang. Paris, 1874.

‡ Gesellius, Die Transf. des Blutes, Eine Studie. St. Petersburg and Leipzig, 1873.

§ Schléep, Berl. klin. Wochenschr, 1874. No. 3.

‖ Eulenburg und Sandois, Die Transfusion, des Blutes. Berlin, 1866.

¶ Uterhart, Berl. klin. Wochenschr, 1868. No. 10.

** Braune, Arch. für klin. Chirurgie. Bd. VI.

†† Casse, De la transf. du sang. Mém. presenté à l'acad. royale de méd. de Belgique le 29, Novembre, 1873.

‡‡ Pueter, Die arterielle Transfusion. Arch. für klin. Chirurgie, 1870. Bd. 12. S. I.

—Transfusion of animal blood to man. This comprises: (*a*) All of those direct transfusions made with intact arterial blood (see Hasse's Monograph *). (*b*) A great part of the arterio-venous transfusions of intact blood, by means of pumping apparatus; (*c*) Injections of defibrinated animal blood and of the serum of animal blood.

How shall we select the most rational procedures, and upon what principles shall we judge of their utility?

The object of transfusion is the introduction of viable red blood-discs, which are destined to serve respiration and the metamorphoses in general. To these ends, it is necessary that the blood-discs be in a liquid favorable to their existence and that the recipient's blood be not of such a character as to endanger their vitality. It is well known that the power of resistance of the blood-discs differs in different animal species, and that the serum of different kinds of blood does not injure the blood-discs of a number of animals, while other blood-discs invariably die in it. These facts are of the greatest possible importance in transfusion of animal blood, because perhaps the blood-discs of the organism which requires blood will not be affected by the injected blood (*e. g.*, lamb's blood). Again, the injected blood-corpuscles can retain their vitality but a short time in human blood. Landois † asserts that the reverse condition prevails when dog's blood is employed.

Among other points which must be considered, are the gaseous constituents of the blood (Brown-Séquard, *l. c.*, and Panum, *l. c.*). The dyspnœa which has often been observed in most alarming form after transfusions with lamb's blood, has been attributed to the large amount of carbonic acid which it contains. This called forth Traube's proposition to render the animals apnœic previous to performing the transfusion.‡

Alexander Schmidt's§ investigations of the fibrin-ferment and its tendencies to the furtherance of coagulation, resulted in new views as to the utility of defibrinated blood.

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* Hasse, Die Lamenblut Transfusion beim Menschen. St. Petersburg u. Leipzig, 1874.

† L. Landois, Die Transf. des Blutes. Leipzig, 1875.

‡ Küster, Ueber die directe arterielle Thierbluttransfusion. Verh. der deutschen Gesellschaft, f. Chir. III. Congr. 1874.

§ Alexander Schmidt, Die Lehre von den fermentativen Geriunungserscheinungen u. s. f. Dorpat, 1876. (Also cites some original investigations upon which it is based.)

Coagula within the circulating apparatus, which have been observed after the transfusion of beaten blood, are attributed to faulty procedure, especially defective filtering off and allowing the transfused fluid to regain coagula. Thence the transferred coagula of fibrin should give rise to further coagulation, as the plugs of fibrin, even if they appear as simple emboli in a larger quantity, would not be followed by threatening phenomena. A. Schmidt has shown that the defibrination of blood may generate fibrin-ferment, and that, as soon as it is introduced into the circulation, may produce multiple coagula. It is probable that a febrile state of, or septic processes in the donor, increase the coagulating power of the fibrin-ferment. Possibly similar conditions in the donor may increase the quantity of the fibrin-ferment in the defibrinated blood (Köhler,*.) According to Köhler the activity of the blood containing fibrin-ferment is also increased, if, upon injection, it is allowed to traverse a peripheral capillary region of the body, as, for instance, injection into the peripheral end of an artery, as Hueter proposes for his arterial transfusion. But periphero-arterial transfusion should preclude the introduction of coagula into the vessels, as the capillary net would intercept them. Aside from the fact that the difficulties of forcing defibrinated blood into a capillary region ofttimes become great and even unsurmountable, which may be attributable to a spasm of the muscles of the vessels as well as to coagulation, within these regions, Schmidt's experiences must cause us to decide against Hueter's method.

The danger in a transfusion of defibrinated blood is not in introducing the retained coagula, but the fibrin ferment formed by defibrination. Its activity is materially increased in peripheral arterial transfusion. Landois's (*l. c.*) proposition, to inject into a large vein or the central end of an artery, whenever the surgeon is compelled to employ defibrinated blood, appears far more rational. This proposition, curiously enough, has met with no further indorsement, though it is easily proven that blood loaded with fibrin-ferment entirely loses its coagulating properties as soon as it is injected directly into an artery, towards the heart.

A syringe must be used for central arterial transfusion,

* Köhler, Ueber Thrombose und Transfusion, Eiter und Sepitische Infection. Inaug. Diss. Dorpat, 1877.

and the danger of forcing in air-bubbles is not so great as when the injection is made into a vein which might conduct the air into the right heart.

Venous blood-infusion admits of but two serviceable procedures, viz., the direct admission of the arterial stream impelled by the vis-a-tergo of the donor's heart, and secondly, allowing the defibrinated blood to press its way into the vein by its own weight as it rests in the measuring-recep tacle. As has been stated, the first method has as yet been employed only in transfusion from animal to man. Still, in an emergency, there would be nothing to preclude the same procedure in transfusion from man to man. A canule might be introduced, with all antiseptic precautions, into the central end of the radial artery of a healthy donor and be united with another which has been fastened into the median basilic vein of the patient, after the hand of the donor has been firmly bound to the arm of the recipient. This, like all other direct transfusions, may be performed without complicated apparatus; easily made glass canules, united by rubber tubes, suffice. Preparatory filling of the canules with an indifferent liquid is unnecessary. A sound inserted between the peripheral canule (*i. e.* the one in the vein) and the rubber tube, amply suffices to prevent the introduction of air, the operation being performed as follows: while the vein is still tied the artery is opened, and the blood, shooting into the canule, crowds out the air before it. As soon as drops of blood instead of air issue at the side of the sound, it is to be withdrawn, as then the connections are filled with blood. All that is requisite then is to loosen the ligature which confines the veins, and the arterial blood will flow unimpeded into the venous territory towards the heart.*

Direct conduction from artery to artery will be found possible only in those cases in which the arterial tension of the donor is greater than that of the receiver. Thus, in a profound anæmia it might be essayed, transfusing blood directly, that is, through simple canules from the central end of an artery of the donor into the peripheral end of the artery of the receiver. When the tension of both arterial systems is equal, the effort will prove futile. In the human being these transfers have as yet been made only by means

* V. Transfusion und Autotransfusion. Sammlung klin. Vortrüge, No. 86.

of pumping apparatus (Schliep *l. c.*). If it be decided to employ such a forcing apparatus at all, we would recommend central transfusion, *i. e.*, from the central end of the donor's artery to the central end of the receiver's, as being a method of easier execution.

Formerly syringes were used for the introduction of defibrinated blood into the veins. But far simpler and less dangerous than thus to force in the blood, is to allow it to flow in, impelled only by its weight and the pressure it exercises upon the vessel which contains it. There is no danger if the blood carry with it a few isolated air-bubbles, especially when the transfusion is made into a vein distant from the heart, as are the veins of the extremities. But when a syringe is used, the force to be employed for the injection of each quantity of blood cannot be so exactly calculated as to assure against overfilling the right heart, with consequent phenomena of engorgement in the large venous trunks or even a direct forcing of blood into the latter, as for instance the portal system. Experiments made in this procedure have yielded observations of hæmorrhage into the intestines and liver, even to the extent of tearing the latter organ (Casse, *l. c.*).

The danger, resulting from the introduction of air into veins have had their fatal issues explained in many ways. First, it is claimed that the air-bubbles which arrive into the heart are forced thence into the lungs and there produce a stoppage in the capillaries, with marked hindrance to the pulmonary circulation. But Löwenthal,* has shown that animals subjected to the injection of large syringefuls of air into the peripheral veins bear the operation quite well. Furthermore, it is known that even an inundation of the pulmonary circulation, as, for instance, with emulsions of fat or wax, is not followed by any direct danger to life.

Panum and others have assumed not only these impediments to the pulmonary circulation, but also a similar circulatory disturbance within the brain, and those nervous centres which are prolonged into the spinal marrow. This can be demonstrated experimentally and graphically (Couty†), especially when air is gradually forced into the veins.

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* Loewenthal, Ueber die Transfusion. Inaug. Diss. Heidelberg, 1871.

† Couty, Etude experim. sur l'entrée de l'air dans les veines. Paris, 1875.

Yet those cases in which sudden death follows the admission of air, show that the primary cause is found in a pure arrest of the heart's action and must be taken into consideration in connection with such fatal mishaps as may occur in transfusions.

The valves of the heart, of which the tricuspid is most important in this connection, are destined to arrest fluids or let them pass. If air instead of blood enters the heart, the valves, especially the tricuspid, become insufficient in proportion to the abnormal distension, the degree of which depends upon the quality of air and blood which have entered the heart. The contractions of the distended heart are not capable of propelling the blood to the pulmonary vessels and beat the blood in its right side to a froth. *Owing to the valvular insufficiency the abnormal contents of the right heart are thrown to and fro between the pulmonary artery and venæ cavæ.* But few bubbles of air or froth reach the pulmonary circulation and the coronary vessels. The air-bubbles do not prevent the blood from entering the lungs and nutrient vessels of the heart, but the valvular insufficiency allows no blood to flow into the heart from the venæ cavæ. Thus the entrance of air into the heart kills by primary paralysis of the organ, provided that *large* quantities have entered at once. When small quantities of air enter the heart slowly, the blood which enters with it prevents the rapid death of the heart-muscles and does not give rise to a definite interruption of the pulmonary circulation. If, after longitudinally dividing the sternum of an animal, the heart be exposed without opening the pleura, and air be allowed to enter the heart through a wound in the jugular vein, the ineffectual efforts of the heart to contract upon its contents become evident. Gradually the coronary vessels fill with air or bloody froth and soon contractions cease entirely. If then an indifferent fluid, say a one half per cent chloride of sodium solution, be injected by a fine instrument through the heart-muscle directly into the right ventricle to such an extent as to overbalance the air in quantity, the following phenomena will be observed: the contents of the heart are gradually pushed forward by weak contractions, as the valves again become sufficient; soon blood follows, the cardiac impulse becomes stronger and the pulmonary circulation is re-established. Further investigations will be required to demonstrate to what extent and in what manner the above observations may be practically applied, and

whether at all life-saving results will be attainable in sudden deaths from the entrance of air.

We will now mention two methods which have been essayed as substitutes for the injection of blood into the vessels, viz.: Subcutaneous injection of blood and injection thereof into the abdominal cavity.

Both methods, whether intact or defibrinated blood is used, yield absorption of the red blood-discs by the circuitous route of the lymphatics. Thus the red discs enter the circulation indirectly and but slowly, therefore these methods are not available for those cases in which a rapid restitution of blood is urgently necessary. Casse* and several others have injected blood subcutaneously in experiments and in patients, but the results were very doubtful. The sites of injection were repeatedly affected with abscesses. It is claimed that Ponfick † injected blood successfully into the abdominal cavities of three patients. Browicz and Obalinski ‡ have proved the latter experimentally.

In proceeding to the discussion of the performance of transfusion, it must be noted that *the vessel into which the injection is to be made, must be well dissected out as in ligations;* and this applies to veins as well as arteries. The use of canules to penetrate a vein through the skin is unsafe and may even become dangerous when large arteries are near, as in the bend of the elbow. After the artery or vein has been dissected from its surroundings, three ligatures are placed about the vessel thus isolated, one peripherical ligature closing the vessel permanently, one central temporary ligature, and between them a thread with which to fasten the infusion canule into the vessel. The canule is inserted into the vessel after the wall thereof has been incised with a fine scissors. The direction of this incision is made diagonal to the long axis of the vessel. After the transfusion is made the temporary (central) ligature is tied firmly, then the canule is extracted, and finally the vessel is cut between the two ligatures. All arteries into which transfusions have been

* Casse, De la valeur des injections du sang dans le tissu cellulaire sonscutané, Bull. de l'acad. royale de med. de Belgique, 1879. T. xiii. 3 ser. No. 7

† Ponfick, Breslaner, ärtyl. Zeitschrift, 1879. No. 16.

‡ Obalinski, Experimentelles Beitrag zur peritonealen Bluttransfusion. Przegled lekarski, 1880. No. 9, art. 10 (Polish). Compare also: Nikolski, Ueber den Einfluss der Blutinfusion in die Bauchhöhleets. Wratsch, 1880. No. 4 (Russian).

made must be so treated, while when a vein is used, the canule may in many cases be merely pushed into the lumen of the vessel without securing it further. After the canule is removed a simple compress upon the site of operation will suffice.

The choice between defibrinated and intact blood merits separate consideration. We have seen that the use of beaten blood does not appear less recommendable because the fibrin is removed, but because fibrin-ferment is developed by the beating and may lead to the formation of coagula. This coagulation within the vessels is blamable principally for the fatal issues of cases in which defibrinated blood was transfused, and not, as was formerly assumed, a consequence of the introduction of flakes of fibrin into the circulation, the presence of which was attributed to defective filtration. Still special care must be devoted to ensuring thorough filtration. For this purpose filters of satin, from which the sizing has been removed, are most recommendable. The filter is set into a glass funnel whence the blood flows into a most carefully cleaned glass vessel. The blood is best beaten with two thick, thoroughly cleaned glass rods, in a porcelain dish into which the blood of the donor was received. Too little time must not, by any means, be spent in defibrination, lest secondary coagulation take place in the defibrinated blood. The glass vessel into which the blood has been conducted after defibrination and careful filtering, need not be specially warmed, as was formerly strenuously urged. No evil results have followed the injection of blood which corresponded to the temperature of the room, as Polli* formerly, and Casse (*l. c.*) recently proved. Oré,† Duranty,‡ Schliep (*l. c.*) and others, have proven the fact that when using intact blood cold retards coagulation. Therefore they recommend that the transfusion apparatus, after being filled with blood be laid on ice, previous to its employment.

When a syringe is employed for transfusion, blood must be introduced slowly and at intervals, to avoid, as before indicated, the dangers of overfilling the portal circulation, or even rupture of the liver. Yet frequently tenesmus, colics and vomiting supervene. These can be avoided by emptying the bowels previous to the operation.

* Polli, Glorie e sventure delle transfusione. Armali universali de medicina, 1854, and in the Archives gen. de med. 1854. Oct. et Nov.

† Oré, Gaz. des hôpit., 1865. Décembre 30.

‡ N. Duranty, Thèse de Paris, 1860.

Among the other symptoms which may arise at a transfusion, we will mention: *dyspnœa*, which, at least in the transfusion of lamb's blood, is attributed by Traube (*l. c.*) to its containing greater quantities of carbonic acid. The *lumbar pains*, which have been explained on the score of renal hyperæmia, as hæmaturia, often follow transfusions. Frequently a rigor follows some time after a transfusion, and later, especially after transfusions of lamb's blood, the entire skin of the receiver has been covered with violently itching wheals of urticaria.

What, then, are the indications for the introduction of viable blood into the circulatory apparatus? The preceding considerations will indubitably have shown you that a marked degree of *anœmia* gives the principal indication. We would also transfuse in extensive deep burns, as in severe cases the fatal termination is brought about by the death of a large number of red blood-discs (Ponfick,* L. von Lesser †).

Thirdly, transfusion is suggested in poisonings, which, as in extensive scalds, alter the capacity of many red blood-discs to perform their functions and produce acute functional oligocythæmia (v. Lesser, *l. c.*) In this connection poisoning with carbonic-oxide-gas merits serious consideration, which Claude Bernard ‡ compared with extensive venesection. Furthermore, there may be discussed in this connection poisoning with chlorate of potash (Marchand §), pyrogallic acid (Neisser ‖) and nitro-benzole (Yüdell, Filehne¶) in all of which analogous destruction of the blood-discs has been established.

Again, transfusion is demanded in poisonings with matters which, owing to their presence in the blood, thence influence the nervous centres. Such are chloroform, opium and its alkaloids, strychnia, etc. In these cases it is necessary quickly to abstract large quantities of blood and thus remove with it corresponding quantities of the noxious substances it

* Ponfick, Amtlicher Bericht der 50 Naturforscherversammlung in München im Jahre 1877, p. 259.

† L. v Lesser, Ueber die Todesursachen nach Verbrennungen. Virchow's Archiv. Bd. 76.

‡ Claude Bernard, Leçons sur les ahæsthésiques et sur l'asphyxis. Paris, 1875.

§ Marchand, Virchow's Archiv. Bd. 77. 3. Heft.

‖ Neisser, Zeitschrift für klin. Medicin. Bd. I. 1 Heft.

¶ Filehne, Ueber die Giftwirkungen des Nitrobenzols. Brchif. exper. Path. und Pharmakol. Bd. xi.

contains. The loss of blood must be covered by a corresponding introduction of healthy blood from without. In those intoxications with such matters as have been mentioned, (carbonic oxide gas, chlorate of potash, pyrogallic acid, nitrite of amyl—and in burns as well) which threaten life almost only through the death of the blood-discs, venesection previous to transfusion is indicated only to lighten the labor of the kidneys, which almost alone must devote themselves to the elimination of the products of the disintegration of the red blood-discs.

In accord with our explanations of the capacity of the vascular system, depletion previous to transfusion, even of great quantities, would, as is self-evident, be quite out of place in the anæmia following hæmorrhages.

Previous to again directing our attention to anæmic conditions, we must now mention one indication for transfusion, which we intentionally omitted when citing the others. The history of transfusion presents frequent reappearances of the suggestion of injection of blood in chronic diseases. As yet, we know but little of the distinctive modifications which the functions of the red blood-discs suffer in various affections. Equally limited is our information upon the influences of these disturbances upon the changes which modify metamorphosis and the several tissues in chronic affections. Therefore the injection of blood in chronic diseases cannot be considered other than an empirical measure.

We must likewise decidedly regret the opinion which occasionally is still uttered, that an introduction of blood in starvation can elevate nutrition. This view has been thoroughly refuted by Casse's (*l. c.*) experiments, as well as by Panum's * classical investigations. The animals which he had starved could in no manner be kept alive by transfusion. The injected blood at first increases the destruction of albumen through its greater oxidation, and owing to the lack of those albuminous matters which should be introduced with normal nutrition. Then, again, we have demonstrated that the excessive red blood-discs are subject to destruction, with concurrent increase of nitrogenous elimination through the urine (Worm-Müller †). Now, if we return to direct anæmia, we distinguish, in accord with Worm-Müller's the-

* Panum, Virchow's Arch. 1864. Bd. 29.
† Worm-Müller, Transfusion und Plethora. Christiania, 1875.

ory on the capacity of the vascular system (*l. c.*), three territories of anæmia.

I. Passive anæmia affecting loss of blood of from one and a half to two per cent of the weight of the body. Most frequently a spontaneous re-establishment of the blood-constituents takes place, as, for instance, after syncope, etc.; therefore we may designate this territory as the physiological stage of anæmia.

II. Anæmia threatening life in which the loss of blood is as much as three per cent of the weight of the blood contained in the body. As we have seen that this is the limit in which the pressure of the blood and the number of the red discs in it suffer sudden diminution, dependent on a peculiar distribution within the vessels, we will in view of that distribution perhaps be able to avoid danger by auto-transfusion without being compelled to introduce blood from without. Auto-transfusion will shortly be discussed in detail.

III. *Fatal Anæmia.*—This is the true domain of transfusion, in which it only and alone can save life, because auto-transfusion will neither bring about an elevation of the blood-pressure nor be able to reproduce a proper admixture of its constituents, which approximates the normal condition. (Compare von Lesser, Transfusion und auto-transfusion, Sammlung Klinischer Vorträge, No. 86; and see the following chapter on auto-transfusion).

We have just seen that loss of blood within a certain limit can be replaced from without by conducting to the heart the blood which has been accumulated in certain vascular districts, as the consequence of sudden sinking of the blood-tension resultant upon the hæmorrhages which have reached a certain degree. And when centripetal expression of the extremities by kneading and likewise pressing the abdomen was practised, elevation of the blood-pressure and greater filling of the aorta was attained, as has been shown you in the second lecture. Importance does not attach to blood which normally is found in the said parts, but only to a local stasis, while the aorta system is but slightly filled. When fatal hæmorrhage occurs under such disturbances of the blood-distribution an anæmic individual will die if the necessary assistance be not given him, and yet may possess a sufficiency of blood to maintain life had the blood been properly distributed. *The patient dies not from lack of blood, but from lack of blood-circulation.*

Auto-transfusion as a means of restoring engorged quantities of blood to usefulness to the organism was first subjected to scientific explanation through the works of Worm-Müller (*l. c.*). It was long known and practised as a popular remedy, especially in hæmorrhages, during and after parturition (Hausmann*).

The proper field for auto-transfusion is that anæmia which endangers life (second territory). In this a key to the quantity of blood of which the body can still dispose is given us. As is self-evident, auto-transfusion is most efficacious in the lightest forms of transitory anæmia (first territory). In those cases in which the effect of auto-transfusion is so limited that for the purpose of saving life which is being extinguished, we must bring blood from without as quickly as possible, auto-transfusion serves as a positive means of diagnosis to indicate to us the quantity of blood which we should introduce. For this purpose it is better and more reliable than the symptoms of hæmorrhage which the pulse and other means furnish, as they depend to a great extent upon nervous reflex. In these cases also auto-transfusion will be of great use as a preparation of the patient for transfusion. It also subserves the purpose of forcing into the circulation all of the blood which remains in the body, and thus to sustain life until the injection of blood can be made.

Furthermore, the execution of transfusion is recommendable in all cases of profound anæmia which are to be subjected to operations in which hæmorrhage is inevitable (extraction of the child in placenta-prævia and after, hæmorrhage, etc.). Finally, it should be used in profound anæmias previous to the administration of chloroform, which, as is well known, diminishes the blood-tension and may lead to a deadly collapse in those who have been exhausted by loss of blood (see Koch, Ueber das Chloroform und seine Anwendung in der Chirurgie. Sammlung Klinischer Vorträge, No. 89).

Auto-transfusion is very simply executed. The patient is placed with his head lower than his pelvis. The extremities are elevated singly or together to the vertical posture, and either bandaged or stroked from the periphery to the centre. Hereto are added kneadings of the abdomen and

* Hausmann, Zeitschrift für Geburtshilfe und Grynäkologie. Bd. I. Heft. 2.

a progressive pressure on the intestines from the symphysis pubis to the margin of the ribs and special compression of the region of the liver. The thorax should also be compressed from time to time by pressure upon the ribs in the axillary line, as in Marshall Hall's Artificial Respiration, the action of which most probably favors respiration, but indirectly, while it principally facilitates the flow of blood to the right heart. Undoubtedly the action of direct mechanical pressure upon the heart assists in this procedure (Böhm*). From time to time the head should be elevated for brief moments so as to allow the blood of the jugular veins to arrive at the heart more quickly. Nélaton's suspension by the heels in the asphyxia of chloroform belongs to the domain of auto-transfusion.

NOTE.—In the preceding footnotes no claim is made to completeness. Fuller bibliographical reports will be found in the monographs of Scheel, Dieffenbach, Martin, Landois, Geselius, Casse, and others.

* Böhm, Centralblatt für med. Wissenschaften, 1874. No. 21.

## LECTURE VII.

*Impediments to the supply of air.—Sudden stoppage thereof in strangulation.—Foreign bodies in the trachea and œsophagus.—Perilaryngeal swelling of the tissues.—œdema glottidis, struma. Kropftod.—Gradual narrowing of the trachea lumen.—Croup and diphtheria.—Paralysis of the vocal cords.—Tracheotomy, preparatory to other operations.—Dilatation of tracheal strictures.—Induction of artificial respiration in chloroform poisoning, opium poisoning, tetanus.—Modus operandi.—Rapid and slow suffocation, their causes and symptoms.—Dangers of suffocation in tunnels and mines; to divers, aeronauts on high elevations; working in compressed air (caissons in bridge-building).—Narcosis in compressed air according to Paul Bert.—Mechanism of artificial respiration.—Opening the cervical bronchus.—Pharyngotomy.—Thyrotomy.—Thyrocricoid laryngotomy.—Cricotomy or crico-tracheotomy.—Superglandular and infra-glandular tracheotomy.—Procedures in tracheotomies.—Bose's rectangular dissection of the trachea.—Insertion of the tube.—Removal of croup membranes and foreign bodies.—Sucking out fluids not to be done in diphtheria.—Dimensions of tubes, and their modes of fastening.—Dressing of the wound in tracheotomy.—Painting it with an eight-per-cent solution of chloride of zinc.—Inhalation through the wound of tracheotomy.—Removal of the tube.—Impediments to respiration after the tracheotomy.—Granuloma.—Strictures.—Posture of the patient in tracheotomy.—Instruments and paraphernalia for tracheotomy.*

GENTLEMEN: A study of the supply of air and early recognition of its limitations is as important a matter for the physician, as is the arrest of hæmorrhages. The correct interpretation of the symptoms in respiratory disturbances, as well as the rapid removal of the cause of disturbance, is ofttimes of the highest importance in the saving of life. This is above all applicable to the sudden deprivation of the supply of air, to which we will now give a detailed attention. Sudden shutting off of the air-supply from the lungs is produced either by a direct narrowing of the lumen of the

trachea or by its compression from without. The latter may be caused by constringent power about the neck, as in hanging or strangulation. In these, if they be adults with ossification of the laryngeal cartilage, we will find peri-laryngeal hæmorrhages, contusions and bloody suffusion of the bronchial mucous membrane, as well as frequently injury to the laryngeal cartilage. In all injuries to the laryngeal structures, whether by gun-shot wounds or blunt missiles projected against the anterior cervical region, we must always perform tracheotomy to guard against the possible apnœa of œdema glottidis.

The tracheal lumen is frequently reduced by the presence of foreign bodies. If these are firm bodies they fall down into the lower part of the trachea, as might coins, beads, pins and needles, bits of bones, etc., or they may occlude the laryngeal entrance, as would large and hastily swallowed pieces of meat. These may be firmly wedged in by the peristaltic action of the œsophagus (from above downwards) or by violent inspiration forced into the rima glottidis and held there by a spasm of the vocal cords. There are many cases recorded in which bits of meat thus caught by the above mechanism have been followed by rapid fatal suffocation. These pieces are usually so firmly wedged in, that though they can be easily reached, the fingers and even forceps will often have great difficulty in removing them, and it may appear impossible. At those moments the pressure of the motions of deglutition added to the spasmodic contraction of the soft palate, which both act upon the foreign body from above downwards, contribute to its perfect immobility. Hereto the circumstance is added that the larynx is pressed tightly against the posterior pharyngeal wall by the muscles attached to the hyoid bone, and thus contribute to the complete closing of the faucial entrance. The foreign body is most easily made movable when the larynx can be drawn away from the vertebra. This is accomplished most quickly by inserting a sharp strong hook in the center of the hyoid bone and forcibly drawing it towards the chin, while a bent forceps grasps the foreign body and endeavors to accomplish its removal.

When foreign bodies have fallen into the bronchus no effort must ever be made to remove them by the mouth. Aside from the difficulty of grasping the foreign body, the manipulations incidental thereto may serve only to force it further down into the bronchial tubes. *When a foreign*

*body is in the trachea, as in injuries to that organ, tracheotomy must be performed as a prophylactic measure without awaiting the œdema glottidis which may supervene.* The site of the operation should be if possible below the place under which the foreign body is presumed to rest. Then it should be endeavored to force it back into the fauces by instruments passed through the tracheotomy-wound. Only when foreign bodies have fallen as far as the bronchial bifurcation will it be permissible to insert forceps or a spoon (Roser†) through the wound, which, in these cases should be one of the infraglandular tracheotomy. However, instruments should not be inserted unless it has been found impossible to dislodge the foreign body and have it fall out through the wound after violent succussion, the patient being suspended by the heels. All voluminous, hard foreign bodies which are wedged in the œsophagus behind the larynx, and compress it, call for tracheotomy previous to making any efforts for their removal. But if those bodies be voluminous yet soft (potatoes, dough), they may be broken up by compression of the throat by the points of the fingers on both sides of the larynx.

Among liquid foreign bodies which reach the bronchial tubes through the larynx and inundate them should be mentioned: water, in drowning; blood, in operations on the facial part of the cranium and in the naso-pharyngeal spaces; pus, upon the bursting of a large retro-pharyngeal abscess, etc. After performing tracheotomy these fluids must be sucked out as much as possible.

Sudden closure of the larynx through *swelling of the tissues* occurs in œdema glottidis, which we have already mentioned as a phenomenon of injuries to the larynx, especially by gun-shot. It also occurs after typhus, most frequently concomitant with ulceration of the arytenoid cartilage or necrosis of the laryngeal cartilages.

Acute narrowing of the bronchial tube occurs in *sudden increase of peri-laryngeal swellings or inflammatory swellings*, as also in rapid pus-formation in Perichondritis laryngea, in Angina Ludwigii (phlegmone colli diffusa), in the rapid

* Falk and H. Kronecker, Ueber den Mechanisms der Schluckbewegung. Verhandl. der Physiolog. Gesellsch. zü Berlin, vom 21 Mai, 1880. No. 13.

† Roser, Vortrag auf dem IX. Congress der deutschen gesellsch. f. Chir. Compare Verhandl. and reference in the Centralblatt. f. Chir. 1880. Supplement to No. 20.

increase of carotid aneurism or rapid enlargement of cervical cysts (dermoid cysts, cysts of the bronchial canal, cystoid lymphangiomata); also in rapidly-growing sarcomata of the cervical lymph glands, and, beyond all, in the rapid growth of strumata, whether they involve inflammatory swelling, or softening within parenchymatous goitre, or a hæmorrhage into the cystic goitre.

An enigmatical form of sudden suffocation in struma called *Kropftod*, has been explained by Rose* as follows: small, hard, fibrinous, scrofulous tumors may wear away places or spots in the tracheal rings, thus causing the trachea to lose its fine spiral, spring-like frame. Then a sudden motion may twist it upon its long axis, or may break it through its transverse axis (*Kippstenose* of Rose).

The last-named causes which produce a compression of the bronchial canal can manifest their results also slowly, thus producing a *gradual narrowing of the tracheal lumen.* The latter, the action of which does not suddenly cut off the supply of air, but manifests itself by a deficient renovation of the air in the lungs, takes place when swellings grow and impinge upon the tracheal entrance as in fibroids of the epiglottis, in fibromata which extend from the posterior nasal spine or in the often very vascular tumors at the base of the skull, the superior maxilla and of the cavernous retromaxillary connective tissue which may gradually fill the entire naso-pharyngeal space. Lingual tumors as well, principally epithelioma, which extend from the base of the tongue to the epiglottis, and finally even swellings and extensive hypertrophies of the tonsils may, because of the gradual impediments which they offer the supply of air, demand a tracheotomy. In hypertrophies of the tonsils it must be particularly considered, especially in very young children where the smallness of the site of operation and the dangers of narcosis under such circumstances preclude the simple removal of the enlarged tonsils.

The reduction of the tracheal lumen caused by pathological processes within the air-tube merit most serious consideration.

Beyond all things *croup* and *diphtheria* must here be mentioned as diseases which, at least in childhood, give the most frequent indication for tracheotomy. It is not our purpose

* Rose. Ueber den Kropftod und die Radicalcur der Kröpfe. Verhandl. des VI. Cong. der deutsch gesellsch. f. Chir. Grössere Vortr. p. 75.

to discuss these diseases in detail. We will but mention that croup occurs almost exclusively in the trachea and shows finely reticulated membranes and coagulated fibrine, which rest upon spots of the basal mucous membrane which have been deprived of their epithelium. Membrane formation also occurs in Weigert's* pseudo-diphtheritis, which is an extension of tonsillo-faucial diphtheria to the larynx. But the membranes cannot be removed during life without damage to the mucous connective tissue upon which they lie. In this instance the membranes consist of heaps of dead round cells which exactly resemble those of the connective tissue. Besides the pseudo-diphtheritic deposits, or often combined with them, is found real diphtheria, that is, rigidity of the superficial layers or the mucous stroma itself in a mass resembling coagulated fibrine and in which but few or no visible nuclei are found. The unnucleated mass shows more or less nuclear migratory cells.

The diminution of the tracheal lumen depends in these cases upon an increased thickening of the mucous membrane owing to accumulated croup membranes or through the inflammatory swelling of parts of the mucous membrane, which are found beneath the superficial mucous layers which have been killed by diphtheria, otherwise the croup membranes, which, separate, may occlude in a flap-like manner and thus cause sudden suffocation. On the contrary, in diphtheria the process may extend from the primary bronchi to their ramifications within the lung and thus reduce their lumen and consequently diminish the breathing surface.

Tumors which grow within the larynx can bring about gradual narrowing, as, for instance, carcinoma of the vocal cords, in which, when it is impossible to operate on them tracheotomy would be in place, while when they are still in local limits extirpation of the trachea should be performed. Again benign proliferations of the tracheal mucous membrane, as developed at the margins of a tracheal fistula in the form of glandular polyps, may reduce the volume of the trachea partly because their narrow stem upon a broad base may throw them upwards with expiration and thus plug the trachea, intercepting the further supply of air.

Special distinction is required in *paralysis of the vocal cords.* This may be the result of paresis, of inaction from contin-

* Weigert, Virchow's Archiv. Bd. 70 and Bd. 78. Heft 2 (1878.)

ued wearing of a tracheal tube and where the tracheal muscles have been subjected to prolonged inactivity. From these should be distinguished pareses partly of central origin, partly in consequence of compression of the recurrent nerves, as, for instance, through the growth of œsophageal carcinoma, or, through aneurism of the bulbus aortæ, which compresses the left recurrent nerve. In the latter case the increasing dyspnœa will finally demand tracheotomy, while paralysis inactivity should be treated by electricity.

*Strictures of the trachea,* be they syphilitic, traumatic or of chronic inflammatory origin (Störck) causing increased dyspnœa, demand an opening of the trachea below the constriction which will also subserve the purpose of gradual dilatation of the stricture in allowing the use of tin dilators through the opening made.

Tracheotomy is also required for certain special purposes. Thus, in resection of the superior maxilla, extirpation of laryngeal tumors and of the larynx itself, etc., it serves to chloroform the patient through the tracheotomy tube and at the same time allows tamponing of the trachea, thus impeding a flow of blood into the lungs in the above-named operations. The trachea was occasionally tamponed by means of a double-walled rubber hollow cylinder which was drawn over the tube and inflated when within the trachea. This has now been more correctly substituted, in resection of the superior maxilla, and other operations, by inducing narcosis with morphine and chloroform and maintaining the head of the patient below the level of the body (Rose).

On the other hand, we perform tracheotomy when in the *induction of artificial respiration* an increasing inactivity of the respiratory muscles is found. It is also applicable in chloroform and opium-poisoning, and in tetanus.

We have been taught by the investigations of Scheinesson and others (see Koch, Sammlung. Klin. Vortr. No. 80) that *chloroform poisoning* has as its most important manifestation a primary paralysis of vasomotor nerve-centres, evidenced in considerable depression of the blood-tension, and have recommended auto-transfusion in case these manifestations assume a threatening character. The anæmia of the brain-centres, causing diminution of the blood-pressure might explain the transitory paralysis of the sensory and motor sphere; while the centres, which lie in the medulla oblongata and govern respiration and the movements of the heart

are not affected. When, however, an impedient to respiration occurs, as in defective posture of the head or body of a narcotized patient, or, as we will see, whenever carbonic acid accumulates in the blood, then the centres of respiration and circulation are subject to the paralyzing influences of both carbonic acid and chloroform. Autotransfusion alone would not suffice, then; artificial respiration and kneading of the heart (Böhm, *l. c.*) must be made and thus oxidation of the blood maintained until a sufficiency of chloroform has been eliminated. But autotransfusion and artificial respiration must be persisted in for a sufficient length of time, and life will return, though it had almost ceased for half or even three quarters of an hour; provided, however, that not too long an interval elapsed between the cessation of the heart's action and respiration, and efforts at resuscitation have been begun.

Similar conditions prevail in opium-poisoning and require similar presistance in the execution of artificial respiration. Opium and its alkaloids depress the sensibility of the various nerve-centers, pre-eminently the centre of respiration (Filehne*). In this connection we must consider the profound reductions of sensibility which permit the accumulation of such great quantities of carbonic acid, even in the arterial blood, that the carbonic acid associated with the action of opium can exercise its paralyzing influence upon the tissues and again upon the functions of the centre of respiration and its neighboring nerve-centers. The necessity and efficacy of artificial respiration in opium-poisoning are thus rendered self-evident. It should be continued until the organism has eliminated a sufficiency of the poison. In desperate cases, transfusion should be tried. Poisonings by opium occur not only from swallowing, etc., of large quantities, but also from painting the laryngeal entrance with tincture of opium to reduce its sensibility. The latter region seems particularly prone to produce rapid absorption of the poison.

You see here a rabbit, with which we will demonstrate the points just discussed. It is lightly bound, and its carotid is attached to a mercurial manometer. We will administer chloroform with a proper inhaler. At the inception of narcosis and the incidental excitement, the normal blood-

* Filehne, Ueber d. Einwerkung des Morph. aüf d. Athmung. Arch. f. experius. Pathologie u. Pharmakol. 1879. Bd. X and XI.

pressure and respiration are transitorily increased, but soon again become normal. The blood-pressure alone soon shows a gradual sinking, while respiration, though it becomes somewhat superficial, remains equable and quiet. After the animal has become motionless, and corneal reflex action can no more be elicited, the pressure sinks lower and lower in the direction of the lowest point. The pulse-waves become smaller and about one half less frequent; respiration becomes deeper and very frequent. Finally the pulse is hardly perceptible, and the respiration, despite its frequency, appears flatter and flatter. When the blood-pressure amounts to but about 10 mm. mercury, the curve shows neither pulse nor respiration. If this condition were continued, the individual would be irretrievably lost. But we elevate the animal's legs and depress its head, and while an assistant exerts pressure upon the legs and body (periphero-centrally), we open the trachea as rapidly as possible and induce artificial respiration. Gradually elevation of the blood-pressure occurs; pulsation becomes visible again, and occasionally single, spontaneous inspiration occurs. We continue auto-transfusion and artificial respiration energetically; the number of pulsations and respirations becomes greater, each respiratory and heart-movement stronger; blood-pressure rises still more, sensibility returns to the cornea—the animal is saved.

I have not succeeded in demonstrating an alteration of the blood-mixture during depression in the blood-tension in a narcotized animal, though I have made experiments to elicit an increase or decrease in the number of the red blood-discs, during narcosis. (Compare Von Lesser, Die Vertheilung der rothen Blutscheiben, etc.)

In like manner it could be shown you that the heart's action and respiration, which were arrested by opium-poisoning, can be re-established by persistent execution of artificial respiration, and the individual called back to life thereby. I beg you to impress this advice prominently in your minds, and that you will not lose time when treating poisonings with the alkaloids of opium, by the administration of atropine or electrical irritation of the phrenic nerve, but that you will tracheotomize and induce artificial respiration as soon as possible. At the same time the above-named adjuvants may be applied as well. When large quantities of the poison have been taken, and even long-continued artificial respiration appears useless, you must,

as has been mentioned, remove goodly quantities of the poisoned blood, and substitute it with approximately equal large quantities of the normal blood of another individual.

In tetanus as well, artificial respiration, especially in acute cases, appears the only means which can be expected to maintain life. The sub-acute forms recover, as we know, either spontaneously or as the result of the application of various, mostly narcotic, remedies. This gives us a large number of remedies, and the numerous descriptions of recoveries under them—chloroform, chloral, opium, calabar, curare, etc. In acute tetanus all of these remedies are useless. Even nerve-stretching in acute cases has thus far yielded but doubtful results.

To thoroughly establish the indications for tracheotomy we must elicit in detail what the consequences of impeded respiration would be. To this end we will recall the incident of rapid suffocation, as well as those in which there is gradually increased difficult respiration.

Our atmosphere is composed of a mixture of twenty-one parts of oxygen and seventy-nine parts of nitrogen, with more or less contaminating gaseous admixture. It furnishes to our organisms—*e.g.*, principally the blood—its oxygen, and returns to the atmosphere the final result of the metamorphoses—carbonic acid. The exchange of atmospheric air and that of the lungs is brought about by the respiratory movements. The renewed air in the bronchi, which, when within the pulmonary alveoli, is brought into close contact with the blood flowing through the pulmonary arteries, exchanges gaseous constituents by diffusion.

The quantity of oxygen in serum and in plasma is but slight, perhaps reaching two or three per cent in volume. Serum which has simply absorbed oxygen can take up only as much as water can. Almost the entire oxygen of the blood appears combined with the hæmoglobin of the red blood-discs as oxyhæmoglobin. Its percentage is fifteen to eighteen in arterial blood, and ten to five in venous blood. This combination is independent of the pressure of the oxygen in the atmosphere, and it is so constant that whether respiration takes place in oxygen or in atmospheric air the arterial blood can take up no more oxygen. The quantity consumed in twenty-four hours is invariable. The organism is thus capacitated to entirely consume the oxygen within the space in which breathing is performed. If, however, the amount of oxygen in the air respired is decreased, the

blood does not take up in each unity sufficient oxygen to satisfy the coincident need of the organism for oxygen. When eleven per cent in volume of the atmospheric air consists of oxygen, breathing becomes difficult. When the percentage in volume sinks below six, the limit of possibility of life therein may be reached, especially if respiration be performed in a closed space where the partial pressure of oxygen rapidly falls to 45 mm. mercury. If the supply of air be suddenly interrupted, the oxygen of the air in the lungs will be almost entirely consumed. Likewise, the amount of oxygen in the venous blood can sink to nothing.

The proportions of carbonic acid in the blood are dependent upon the proportions of the carbonic acid in the atmosphere, subject also to influences of the temperature. Thus we ordinarily find in the lymph and serum perhaps as much carbonic acid as water would take up (100 per cent at a low temperature, and seven per cent at high bodily temperature).

The blood can take up altogether 150 to 180 per cent in volume of carbonic acid at a medium temperature and barometric pressure, because of the salts—phosphates, carbonates—which it contains, loosely combined with a part of the carbonic acid and bi-carbonate of soda. Finally, a third part of the fixed carbonic acid can leave the living blood through the action of oxyhæmoglobin.

The essentials to an accumulation of carbonic acid in the blood lie in its saline constituents and defective arterialization, when such occurs.

In an atmosphere where there is a paucity of carbonic acid the blood contains only such acid as it has absorbed in diffusion. The tension of $CO_2$ in the blood amounts to between 30-90 mm. Hg; that in the atmosphere varies between 25 and 60 mm. Hg; thus the slighter and varying difference must be compensated by the other forces which derive carbonic acid from the serum if a sufficiently continued decarbonization of the blood is to take place.

The amount of $CO_2$ in arterial blood is between 26 and 30 per cent. in volume, while the venous blood contains about 4 per cent. more. Upon suddenly closing off the respiratory passages the amount of $CO_2$ in the blood rises to about 53 per cent in volume, but not higher. The individual dies for lack of oxygen before the carbonic acid can exert its toxic influences upon the organism.

The conditions are different when only the elimination of carbonic acid from the blood is impeded. We will call this impediment "slow suffocation," which consists either in an accumulation of carbonic acid in the surrounding atmosphere, as, for instance, upon enclosing an individual in an hermetically sealed space; or the carbonic acid may escape from the lungs in but insufficient quantities. Hereto contribute gradual contractions of the larger air-passages, as, for instance, in croup and diphtheria, or it is owing to inactivity of the respiratory muscles, as we find it in poisoning by opium or chloroform.

In slow suffocation the paralytic action of carbonic acid is evident, because, despite the insufficient removal of carbonic acid, there yet reaches the blood sufficient quantities of oxygen. *Death from slow suffocation is a paralysis in consequence of the continually increasing carbonic-acid poisoning of the nerve-centres.*

When the accumulation of carbonic acid is gradual, and the atmospheric air contains sufficient oxygen, the stage of excitement and convulsions may not occur and death may take place, accompanied by paralytic manifestations during apparent subjective health of the patient. We should impress our minds with a very distinct picture of this condition, so as to be prepared for the frequent and apparently unexpected deaths in diphtheria. Then we can save many a young life by a properly timed tracheotomy, and will not need to accuse ourselves of having taken operative measures "too late" because of our defective knowledge of the symptoms of gradual carbonic-acid poisoning.

At the beginning of narrowing of the larger air-passages those nerve-centres which are still intact rebel against the limitation of the supply of oxygen through symptoms of moderate dyspnœa with a general restlessness. The little patients suffer insomnia, throw themselves about and alternate the horizontal position with the erect. The deepened respiration is accompanied by motions of the alæ nasi and perhaps also with contraction of the scrobiculus cordis and of the jugulum (fossa suprasternalis). But as the air-tube contracts still more, the picture changes. The nerve-centers, influenced as they have been, by the action of $CO_2$ have accommodated themselves to the diminished supply of oxygen. The child becomes quiet, it does not change its posture so frequently, notwithstanding the increased dyspnœa and despite the augmented contractions of the

thorax. Somnolence and apathy to surroundings occur, the temperature which at the beginning of the process was markedly increased, now shows a considerable reduction below the normal. And thus death occurs imperceptibly, while breathing becomes flatter and reduced in frequency and the pulse finally is but filiform. If tracheotomy be performed in this stage the operator must be prepared to experience a failure, because of the advanced paralysis of the nerve-centers by carbonic acid. Thus the operation should not be deferred beyond the stage of excitement unless in exceptional cases.

It is unnecessary to detail the symptoms of sudden suffocation. We have mentioned that sudden lack of oxygen is the cause of death. The nerve-centers in these instances are robbed more rapidly of their vitality after they have suffered severe excitement. Thus death occurs with violent muscular twitchings, as is well known in cases of hanging.

As a lack of oxygen kills nervous apparatus more quickly than the gradual action of carbonic acid, we must immediately seek an artificial supply of air in cases of sudden suffocation. It is hardly necessary to discuss the urgency of doing this in hanged people. Cutting the rope will not suffice when an injury has occurred to the tracheal cartilage; the trachea must be opened quickly. The same applies to foreign bodies in the trachea. The manner of treating them has been discussed in detail.

*The symptoms of acute and slow suffocation* are easily demonstrated by *experiments.* The signs of a sudden lack of oxygen, the violent disquiet and labored respiratory movements, then the voluntary twitchings of the extremities which finally become a general convulsion of the voluntary muscles, are observed in suddenly closing the trachea or in plugging the tube which has been inserted into the trachea. The general muscular convulsion is followed by an equally rapid general relaxation; the cornea is deprived of all sensation; and after death we note but isolated fibrillary twitchings of the muscles and increased peristaltic motion of the intestines, as evidences that there still survives in

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Compare C. Friedländer and E. Herter, Ueber die Wirkung de Rohlensäure auf d. thier organismus. Zeitschr. f. physiol. Chemie. Bd. II. pp. 99 to 148. And Ibid. Ueber d. Wirkung d. Sauerstoffmangels, etc. Zeithschr. f. physiol. Chemie. Bd. III. pp. 19 to 51.

the organs an accumulation of venous blood which is overcharged with carbonic acid.

If we wish to observe the consequences of slow suffocation, we have a simple means thereto at hand, viz., attaching an open rubber tube to the one which has been inserted into the trachea. In proportion to the length which we give the tube; that is, in proportion of its contents to the volume of the expiratory air, the different degrees of suffocation can be produced. If the space in the tube is as large or larger than the volume of the expiratory air the latter will be breathed over and over again. The entire volume of air remains within the tube and at each respiratory act, simply moves to and fro. As is evident, the individual must soon be suffocated. If we choose a smaller tube, we can allow a part of the respiratory air to escape and to be replaced by atmospheric air. Thus, according to the length of the tube, various mixtures of expiratory and outer air occur and these serve for respiratory purposes. However, these mixtures become poorer and poorer in oxygen and richer in carbonic acid than our common respiratory air. As long as the blood can secure sufficient quantities of oxygen from these mixtures, neither convulsions nor disquiet appear. But the excess of carbonic acid in these mixtures causes an accumulation of carbonic acid in the organism which finally may become so great that the individual dies under the paralytic influences of carbonic acid, during which respiration and pulsation are gradually extinguished.

This simple experiment, which can be variously modified, indicates to us why permanency in mines and in tunnels appears incompatible with respiration, provided no pumps are employed to supply air to ventilate the surroundings of the living beings, and which would render impossible what we may call endogenous carbonic acid poisoning. Similar considerations apply to divers whose breathing-mask is connected by means of a tube with the surface of the water. But so as to supply these divers with sufficient oxygen, special pumping apparatus must be employed, to furnish air under a pressure which will counterbalance the pressure which the water exercises upon the body-surface of the diver (Paul Bert*).

Furthermore, aeronauts and persons who ascend high

* Paul Bert, La pression barométrique. Paris 1878. p. 410.

mountains suffer more or less grave symptoms, such as vomiting, vertigo, severe pressing headache, bleeding and syncope, (Bergkrankheit), which depend upon a lack of oxygen in the red blood-discs owing to a reduced partial pressure of the oxygen in the atmosphere of the higher strata. Jourdanet* calls this condition *anoxyhémie* and considers it an analogue to anæmia, resultant upon direct loss of blood-discs.

Other accidents, such as we will mention, require a different explanation. We refer to the workers in caissons (within streams, etc.), which are used in the construction of bridges. To allow such laborers to work in the bed of the stream, the atmosphere within the caisson must be sufficiently compressed to counterbalance the weight of the column of water from the surface to the ground. The absorption of carbonic acid into the blood is hardly increased thereby, and the amount of carbonic acid in the blood is not at all influenced. A change occurs in the quantity of nitrogen which is taken up and which is not reabsorbable.† Its quantity is increased by the high compression of the air some four or five times. If the laborers leave the caissons suddenly, without subjecting themselves to a gradual decompression of the air in the caisson down to that of the free atmosphere a large quantity of bubbles of not re-absorbable nitrogen are freed in the blood and drag with them a part of carbonic acid in gaseous form. The same applies when the diver removes his breathing-mask rapidly. The multiple gas emboli produce permanent functional disturbances of various organs, principally paralyses, by rapid death of those nerve-centers which are particularly susceptible to the consequences of a rapid deprivation of blood. In acute cases, death occurs by an accumulation of gas in the right heart and within the cerebral vessels, just as would happen if air were suddenly injected into the veins. In both these organs we find large quantities of bloody froth (compare Panum ‡), besides which the heart presents large quantities of a mixture of nitrogen with some carbonic acid (P. Bert, *l. c.*).

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* Jourdanet, L'influence de la pression. de l'air sur la vie de l'homme, etc. Paris, 2nd. ed. 1876.

† Bert, *l. c.*, p. 964.

‡ Panum, Experimentelle Beitr. z. Lehre v. d. Embolie, Virchow's Archiv, Bd. 25.

Hoppe-Seyler * mentions the phenomena consequent upon liberation of nitrogen in the blood in rapid decompression, as Bert proved them. Paul Bert (*l. c.*, p. 980 and p. 1148) assumes that the elimination of the bubbles of nitrogen from the pulmonary circulation is impeded because the air in the lungs contains a very free admixture of nitrogen and therefore he recommends in cases of too rapid decompression in divers and workers in caissons the *inhalation of pure and preferably compressed oxygen.* He attained good results in removing the bubbles of nitrogen from the pulmonary circulation and partly from the heart of the animals on which he experimented. For the purpose of returning those bubbles of nitrogen from the capillaries and the quantities of nitrogen from the connective tissue into the blood, renewed compression of the air (*recompression*) *followed by a slow decompression,* will be found the only useful means. The same procedure is recommended by Bert, in entrance of air into the veins (compare Couty, *l. c.*, in Sixth Lecture).

An interesting and important application of compressed air has been made by Paul Bert † in the narcosis of nitrous oxide (laughing-gas). P. Bert found that the simple administration of laughing-gas produces a very exciting and even dangerous narcosis, owing to the reduced amount of oxygen which is taken up; therefore he proposed the production of nitrous oxide narcosis with coincident application of compressed air, so as to supply the the blood with sufficient quantities of oxygen while the anæsthetic gas was being applied. These narcoses, which, it is to be regretted, can be produced only in large establishments which possess expensive apparatus for the compression of air, are said to be eminently satisfactory in the course of anæsthesia, as well as in the rapidity of restoring consciousness and the absence of all after-effects (vomiting, headache). Even more extensive surgical operations have been essayed under Paul Bert's ingenious procedure (Péan,‡ Labbé, Deroubaix §).

* Hoppe-Seyler, Ueber d. Einfluss, Weichen d. Wechsel d. Laftdrukes a. d. Blut ansübt. Müller's Archiv. 1857, p. 63 to 73.

† Paul Bert, Sur la possibilité d'obténir, à l'aide du protoxyde d'azote, une insensibilité de longue durée, etc. Comptes rendus, T. 87, No. 20.

‡ Lutand, l'Anæsthesie par le protoxyde d'azote sans tension. Gaz. Hebdom, 1879, No. 14.

§ Deroubaix, l'art médical de Bruzelles, 1880. Mai. Compare also Raphael Blanchard, De l'anæsthesie par le protox. d'azote, etc. Paris. 1880 (aux bureaux du progrès médical).

Previous to considering the operations for opening the trachea let us say a few words about the *artificial insufflation of air after tracheotomy* and the changes which are brought about by it in the circulation. A reversal of the proportions of pressure in the thorax occurs and consequently a similar effect is produced on the circulation. In contradistinction to natural inspiration, artificial insufflation of air produces a positive pressure in the thorax with venous engorgement. After expiration following artificial insufflation a negative pressure with aspiration of the blood occurs in the chest because the absence of activity of the respiratory muscles, allow the elasticity of the lung-tissues to exceed that of the thoracic walls. At all events the condition of the heart and the lungs will have to be observed in reference to the frequency of insufflation of air, the quantity of air to be insufflated each time and the power to be employed.

But few operations of those which are performed to enter the air-tube from without, are suitable for immediate or permanent supply of air.

Opening the pharynx by an incision at the lower margin of, and parallel to the hyoid bone and between it and the thyroid cartilage (Malgaigne's Laryngotomia Subhyoidea or von Langenbeck's Pharyngotomy) is not proper for air supply. Only Vidal recommended it formerly, as a means of catheterizing the larynx through the opened laryngeal entrance (*tubage du larynx.*) It is remarkable that this method was recommended by Hippocrates, to be performed *per os* in danger of suffocation. It cannot be indorsed owing to the lack of safety in its execution and because it takes no consideration of the locality of the impediment. Least of all is it permissible to probe foreign bodies through the laryngeal opening, when they are within the larynx or trachea.

Desault's thyroid laryngotomy is equally improper for our purposes and is useful only for the removal of tumors from the laryngeal space. It is performed by splitting the larynx through its commissure between the thyroid plates. If the tube were to be inserted between the thyroid plates, necrosis of these plates might easily follow as might ulceration of the vocal cords.

The same applies to thyro-cricoid laryngotomy (Vicq d'Azy), or diagonal incision of the conoid ligament, as it would be of no avail for permanently wearing a tube, as

the resultant opening is too small. The operation could be recommended only in sudden asphyxia owing to the superficial position of the conoid ligament and the facility of locating it. Inasmuch as the anastomosis of the thyro-cricoid artery lies upon the ligament, it may be required to ligate the artery doubly and cut it through its middle, before incising the ligament itself. The dimensions of the opening made in the conoid ligament can be increased only by splitting the cricoid cartilage, but the wound will, at best, serve only to suck water out of the lungs through a catheter (as in drownings) or to force foreign bodies which have fallen into the larynx back into the pharynx.

The methods which are employed for *slitting the trachea above or below the thyroid gland* are of particular interest. They are supra and infra-thyroid tracheotomies, or, better, supra and infra-glandular tracheotomies.

Supra-glandular tracheotomy yields too small an opening in children to permit the introduction of a tube. Therefore the orifice in the trachea is enlarged by splitting the cricoid cartilage. Then the tube can be easily inserted. The execution of this operation is as follows: The nail of the left thumb marks the upper margin of the thyroid cartilage, whence the skin is incised in the median line of the neck some three c.m. downwards, laying it open as far as the sub-cutaneous connective tissue and exposing the uniting line of the straight cervical muscles. This line must be carefully sought and separated by two pairs of forceps, or if venous vessels transcourse the median line (V. colli media) it should be drawn apart with dull hooks. If the indication given by this linea alba be not followed an incision might easily be made in the straight cervical muscles of either side which would produce a much stronger hæmorrhage. If we have penetrated the middle line the trachea will be exposed, but more or less covered by the thyroid gland, especially when the isthmus still exists, and then it may cover the trachea entirely (Lissard *). Formerly it was considered necessary to dissect the thyroid gland off, to reach the trachea. This was frequently accompanied by considerable loss of blood and contributed to prolong the operation and increase its difficulties. It has even been proposed to cut through the isthmus after doubly ligating

* Lissard, Anleitung zur Tracheotomie bei Croup. Greesen, 1861.

it to thus expose the trachea (Roser). Bose* merits decided approbation for his retro-glandular method of exposing the trachea, in which the thyroid gland is not dissected from the trachea after splitting its capsule, but it is levered or rtther torn in tact from the anterior tracheal wall. For ais, purpose, after the straight cervical muscles have been pulled apart and the trachea (covered by the thyroid gland) is exposed, a diagonal incision is made through the anterior aspect of the cricoid cartilage at that place where the two layers of the deep cervical fascia are re-united and attached after having separated to form the capsule of the thyroid gland. While the lower margin of the slit thus made is drawn upwards with a pair of forceps, a dull lever (elevator or handle of scalpel) is inserted between the larynx and the posterior wall of the thyroid capsule to tear off the latter sufficiently. Then a strong hook is inserted into the cricoid cartilage and drawn strongly against the chin, out of the wound. The thyroid gland which has thus been torn off with its capsule, is drawn down toward the sternum with a broad dull hook or if necessary a spatula in the hands of a second assistant. While the first assistant's right hand draws the hook which is inserted into the cricoid cartilage upwards, we place a large, sharp strabismus hook in his right hand and grasp a similar one in our left hand. Now the sharp knife in our right hand which is held closely above the protecting plate upon the thyroid cartilage, is inserted into the trachea which it opens by short, sawing motions as far as the cricoid cartilage. Then the surgeon and assistant insert the two sharp hooks into the tracheal wound and the surgeon, in case the trachea is not sufficiently opened to introduce the tube, cuts the cricoid cartilage from below upwards in such a manner as to liberate the thick hook which has been inserted into it. The incision of the cricoid cartilage converts the supra-glandular tracheotomy into Boyer's so-called laryngo-tracheotomy, which is also designated crico-tracheotomy (Hueter). The incision of the conoid ligament, as was made by Boyer is unnecessary.

In children crico-tracheotomy should be performed in recognition of the principle that the tubes should be as wide as possible. The opening thus made is so large that it is

* Bose, Zur Technik d. Tracheotomie. v. Langenbeck's Archiv. f. Klin. Chir. Bd. XIV. pp. 137 to 147.

not only adequate for convenient supply of air but also is useful for the extraction of foreign bodies which have fallen deeply into the trachea, provided there is no swelling of the thyroid gland. Diagonal incisions at the upper and lower margin of the tracheal cut, allowing two lateral tracheal quadrangular flaps to be opened outwards, as recommended by Dieffenbach would be in place only exceptionally when an abnormally large opening into the trachea is required. In infra-glandular tracheotomy the trachea is opened from about its seventh cartilage downwards to the upper margin of the sternum. Some recommend it especially in croup (Wilms *). We prefer crico-tracheotomy in children and people with short necks. Infra-glandular opening of the trachea will be urgently required, where there is a contraction of the trachea in the region of the thyroid gland, in enlargement of the gland or where foreign bodies which have fallen down to the bronchial bifurcation, are to be extracted.

Above the sternum the trachea is covered only by integument and several layers of the cervical fascia. The straight cervical muscles here, are well separated, especially in enlargement of the cervical glands. But between the skin and fascia as also between the various layers of the fascia and the trachea is found connective tissue often full of fat and still oftener traversed by an extensive venous net. The veins may be tensely filled with blood when there is strong dyspnœa. Therefore after the incision through the skin from the sternal notch is conducted four or five c.m. upwards in the middle line of the neck the connective tissue is carefully split, layer by layer, as it is elevated from the wound with two forceps. When an extensive venous net is found dull hooks should be used to crowd the veins apart, and the knife should be employed as little as possible. Furthermore, embedded between the layers of fascia above the sternum a lymph-gland is found, and in it a side-branch of the thoracic duct terminates. The gland is often enlarged. At the lower margin of the thyroid gland the thymus gland is found more or less developed in children. In adults with goitre, enlarged flaps thereof may hang down behind the sternum (substernalis). Occasionally an arterial branch (arteria thyroidea ima) arising

* See several Jahres veriche d. krankenhauses Bethanier zur Berlin in v. Langenbeck's Archiv. f. Klin. Chir.

from the innominate, courses upwards, along the trachea, to the thyroid gland. This arterial branch must not be injured. The tearing of the layers of the connective tissue which cover the trachea produces emphysema of the mediastinal connective tissue, and when the operation cannot be performed with antiseptic precautions, it may lead to formation of pus in the mediastinum, especially in cases of croup or diphtheria of the trachea.

After exposing the trachea it is to be opened in the median line from the sternum upwards, while the lower margin of the thyroid gland is covered by a dull broad hook and drawn up to the chin. During this incision injury to the arteria thyroidea ima must be avoided.

As to further procedures upon opening the treachea at any place, the tracheal wound must be held open with sharp hooks until respiration has again become entirely free. This applies to drowning and croup, or until foreign bodies have been removed through the tracheal opening by long curved forceps or by efforts at coughing. Frequently foreign bodies fall out of the trachea when the patient is suspended by the heels. When sufficient assistants are not obtainable the tracheal wound must be separated by spring instruments resembling palpebral specula (Bose) or with forceps which act similarly (Trousseau). In accumulations of fluids in the lungs (blood after hæmorrhages, pus after evacuated retro-pharyngeal abscesses, water in drowning, liquor amnii in premature respiration of the new-born) efforts must be made to remove them by means of deeply inserted catheters as before mentioned. In croup the membranes must rather be removed by forceps than by suction, because of the irritation and coughing which it would produce by touching the swollen posterior tracheal wall and bronchial bifurcation. In diphtheria suction is useless and reprehensible in the interests of the operator. It is to be regretted that it still figures in many texts and is accompanied by phraseological praises, as a life-saving means. This hare-brained foolhardiness has cost many an operator his life, without saving that of the patient.

When there is no more dyspnœa the tube is inserted. This consists of a double tube bent in a segment of a circle having a movable plate at one end to rest on the skin of the neck. The inner end of the apparatus which is to lie within the trachea has both of its tubes cut off diagonally at a level, or the inner one may project about 1 c.m. from the outer

one, and be rounded off like the point of a catheter with a very large eye. The surgeon should be provided with two or three tubes of diameters, varying from 4 to 6 m.m., so as to be prepared for adults as well as children. The tubes are attached to the neck by broad tapes which are drawn through the holes of the movable plate. The middle of the tape is knotted into the hole of the plate at its anterior part and both ends of the tape are laid around the neck; the inner strip of tape is drawn through the second hole of the plate and then both ends of the tape are fastened together at the side of the neck. The lower corner of the incision can generally be closed with a suture. Beneath the plate of the tube a splint-compress, which should consist of unstarched guaze, may be placed. Both halves of the compress should be sufficiently large to allow them to be folded over the front of the tracheotomy tube. The compress itself should be spread with vaseline, containing either two and one half per cent of carbolic acid or twenty per cent of boracic acid. Over all this the neck should be enveloped several times with a bandage of unstarched gauze, and over the region of the tube it should be moistened with a weak antiseptic solution, such as two per thousand of salicylic acid, two to three per cent of boracic acid, aq. plumbi or diluted vinegar. Instead of these dressings a mere folded gauze compress dipped in an antiseptic fluid, may be laid on the tube and changed as often as it becomes dry.

For several years I have been in the habit of painting the wound with an eight-per-cent solution of chloride of zinc during the tracheotomy. I consider it particularly useful in croup and diphtheria. I apply it at the moment when the trachea is exposed, for instance, as in crico-tracheotomy, when the hook is inserted into the cricoid cartilage, but previous to opening the tracheal tube, thus covering the fresh wound with an antiseptic scurf and preventing contact of the membranes or the secretion of the region affected with diphtheria. Czerny* has employed the same procedure in external urethrotomy when made for impermeable stricture.

As long as it is desired to maintain the tracheal opening, the outer tube is left in it while the inner one is removed as often as the dried secretions or the extended croup membranes narrow or occlude it. It may be cleaned with a con-

* Neumeyer, Inaug. Diss. Heidelberg, 1870.

centrated solution of soda and little brushes, similar to those employed for sucking-bottles. The permeability of the inner tube must be closely watched, because if this be neglected dyspnœa may be easily renewed, especially in children. In croup, inhalations of lactic acid (two per cent) with common salt and diluted glycerine, have been found useful partly to facilitate the solution of the membranes, partly to prevent inspissation of the secretions. These inhalations are of little or no use whatever in diphtheria.

The final removal of the tube is dependent upon the course of the processes of infection. The time for removal of the tube is dependant upon the course of the local processes such as may be influenced by œdema of the glottis, perilaryngitis, enlargement of the strumous tumor, etc. Accumulations of fluids in the lungs allow the removal of the tube sooner. After removal of foreign bodies, resuscitation from chloroform and opium poisonings, the tube can be removed immediately and the soft parts united by stitches, which enclose the tracheal wound. Firm compression by circular bandages around the neck must be made to prevent the entrance of air into the connective tissue of the neck. The time when the canule may be removed after it has been worn for a long time is not determined by simply removing it and observing whether dyspnœa presents itself or not. Especially in children, a return of dangerous suffocation would bring with it great difficulty for the reintroduction of the tube. Only the inner tube should be removed. The outer tube must have an oval opening in its upper wall at the highest point of its convexity so that when the outer opening of the tube is plugged a stream of air can enter by the mouth and nose. Thus the opening may be stopped with a cork which is attached to the outer plate by a thread and the tube thus closed for such periods as the patient can bear. Finally the tube may be stoppered at night, and when it is worn during sleep the outer tube may also be removed. This should never be done without having a hook at hand so as to be able, in an emergency, to draw open the wound for the purpose of re-inserting the tube.

This may be necessary, though respiration appears free, while the stoppered tube is in place, still attacks of suffocation may occur immediately after the tube has been removed, or after the next violent coughing fit. The cause of these suffocatory attacks is found in peculiar stemmed proliferations of the tracheal mucous membranes which are

attached mostly to the lower angle of the wound, while their free pear-shaped end projects into the tracheal lumen. These polypi are forced upwards during violent expiration and their club-like ends plug the trachea. If they are cut, burned, or scraped off they return and force the patient to wear a tube continuously. If a tracheotomy is made lower, the old tracheotomy wound heals rapidly; but proliferations may occur in the new wound as before. As a rule the wounds of tracheotomy contract rapidly after removal of the tube. This contraction can be facilitated by drawing the lips of the wound together with adhesive plaster and by cauterizing the base of the wound with the nitrate of silver stick. Sometimes, perhaps weeks after the wound has healed, gradual contractions of the trachea take place and especially does this occur after diphtheria. It may then be necessary to reopen the trachea. Even without any of the above-named causes, the early removal of the tube may be rendered impracticable through a paresis of the tracheal muscles consequent upon prolonged wearing of a tracheal tube the upper surface of which is imperforate, consequently has allowed the tracheal muscles to remain at rest. In such cases direct electrization of those muscles will most rapidly relieve the respiratory insufficiency. In employing it one of the electrodes is set upon the neck.

In each tracheotomy you will be required to lay the patient on his back, his neck extended and head bent back which is accomplished by placing a round pillow, a rolled-up shawl, or bed-cloth beneath the dorsal aspect of the neck. The best operating table is a narrow, four-legged one, which should not be too long. When sufficient assistants are not obtainable the patient's feet may be tied to the legs at the lower end of the table, while his arms may be fastened together to his back, by cords running through the elbows.

Two reasons may be given why the physician should always have ready in a special case the instruments required for tracheotomy. First, because when a tracheotomy is required, no time must be lost in gathering or improvising instruments. On the other hand tracheotomy being required most frequently in croup and diphtheria, and as the above processes are of an extremely contagious character, it is well to have separate instruments for that purpose.

The simplest case may consist of the following : one sharp-pointed scalpel, one probe-pointed scalpel, one dissecting and two surgical forceps, two thumb-slide forceps, one can-

ulated sound, two sharp strabismus hooks, two blunt strabismus hooks, one sharp hook to draw up the cartilage, two or three tracheotomy tubes, four to six m.m., in interior diameter, one speculum for the tracheal wound, one pair elastic catheters, one roll of tape for fixation of the tube, needles and silk, one scissors, and one or two gauze bandages. The entire case need measure but 32 c.m. in length, 12 c.m in breadth, and five in height, and so arranged that instruments may be placed in its bottom and cover. Some brushes and an eight-per-cent solution of chloride of zinc should not be omitted.

## LECTURE VIII.

*Impeded passage of alimentary substances through the intestinal canal.*—IMPEDIMENTS IN THE PHARYNX AND ŒSOPHAGUS: *Topography of the latter.—The most narrow points in the œsophagus, as seats of foreign bodies, tumors and strictures.—Removal of foreign bodies from the faucial, cervical, and thoracic parts of the œsophagus.—Instruments.*—ŒSOPHAGOTOMY.—*Indications, mode of procedure, after-treatment of the wound.—Tumors of the œsophagus.—Strictures, their Etiology and treatment.*—CATHETERIZING THE ŒSOPHAGUS. GIRARD'S *method.*—IMPEDIMENTS IN THE SMALL AND LARGE INTESTINES.—HERNIAS: *Reducible, adherent, strangulated.—Hernial orifice, contents, sack, neck; cysts of the sack.—Irreducibility, its etiology; adhesions, fœcal invagination.—Strangulation.—Acute and sub-acute strangulation.—Apparent strangulation and its treatment.—Site of strangulation.—Treatment of hernia.*—TAXIS: *Mechanisms of Roser, Busch, Lossen.—Supporting postures in taxis.—False reduction.*—HERNIOTOMY; *No special instruments required.—Modus operandi.—Incisions.—External and internal hernial incision.—Herniotomy.—Débridement multiple.—Reposition of hernial contents.—Condition of the loop of intestine.—Suture of intestine in various forms of gangrene.*—ENTERORAPHY: *Treatment of artificial anus.—Treatment of prolapsed peritoneum.—After-treatment of herniotomy.*—RADICAL OPERATION FOR HERNIA.

GENTLEMEN: At various places in the intestinal canal impediments may occur which hinder or render impossible the carrying forward of such matters as have been taken up, digested, or designated for ejection from the organism. Yet you will find that with a great number of possibilities in reference to the seat of the impediments, a certain regularity occurs, in so far as certain places are particularly favored in the frequent production of such impediments. Let us view the divisions of the intestinal canal separately, in this connection. Where the pharynx goes over into the

œsophagus the diagonally striped constrictor (constrictores pharyngis) muscles are substituted by the smooth muscles of the œsophagus. The œsophagus extends downward behind the trachea, projecting somewhat to the left, and within the thorax runs behind the trachea and left bronchus, while the arch of the aorta lies over the left bronchus, and thus also over the œsophagus. This site belongs to those points in the course of the œsophagus in which, most frequently, impediments to the passage of the food occur. Other narrow points of the œsophagus, we find behind the cricoid cartilage, then behind the entrance of the trachea into the thorax, and furthermore, above the cardiac space and at the passage of the œsophagus through its slit in the diaphragm.

At these places abnormally large morsels and foreign bodies are arrested. We also see that at these places the development of tumors, principally ephtheliomas, is most frequent. They also are the most frequent seat of strictures which form within the œsophagus.

Foreign bodies which enter the œsophagus may first be caught in the glosso-epiglottidean folds, as, for instance, fish-bones. Their removal must be accomplished through the mouth, as must all foreign bodies which reach the fauces, according to the precepts detailed in Lecture VII. Fish-bones, especially, are easily removed by forceps after the tongue has been thoroughly depressed with a spatula. Bodies which have lodged deeper are extracted with special instruments, among which, first, forceps are to be mentioned. The branches of the forceps for this purpose revolve either upon their fulcrum or around their common long axis, or they are constructed similar to the Lithotriptor, in which one branch is made to lock with the other by pushing it forwards. The forceps are intended particularly for rounded or cylindrical bodies. Von Graefe constructed a very useful coin-catcher (Münzenfänger) for coins and similar bodies that are frequently swallowed. This consists of a long staff, one end of which carries two rings, which are soldered at an acute angle. In inserting this instrument below the coins they promptly fall into the mould, and thus can be removed. For the purpose of removing deep-seated fish-bones, Petit devised the so-called chain staff (Kettenstäbchen), of a parachute-like form. The ribs of the parachute consist of movable links of chain which easily catch the fish-bone. Instruments have been proposed for the extraction of voluminous foreign bodies, which were to be opened

below them, as in Weiss's whalebone sound, or they were to be removed by inserting œsophageal sounds, the ends of which were provided with compressed sponge, and the instrument was to be removed after the sponge had swelled, and thus draw the foreign body out with it.

Greater difficulties are experienced in the removal of sharp bodies, such as, for instance, a fish-hook that has been swallowed. If the hook have a string or thread attached to it, balls of glass or lead may be slipped over the string as far as the hook whereby its point is covered, and lesions of the œsophageal walls avoided in its extraction. When no thread is attached to the fish-hook the extraction must be made with one of the above-named instruments (coin-catcher, chain-staff, etc.), but this always must be essayed within a wide œsophageal sound. This corresponds to Dieffenbach's case, who removed an ear of corn which was hooked fast by its grains to the vaginal mucous membrane. He made the extraction simply through a speculum which he had inserted. (Compare also Marchetti's case, cited by Dieffenbach in his Operat. Chirurgie Bd. I. p. 36, who removed a dried pig's-tail from the rectum of a young girl in a similar manner.)

Very soft voluminous bodies can be broken up in the cervical part of the œsophagus by a simple pressure of the fingers, as has been mentioned before (Dupuytren, von Langenbeck). When such bodies are in the thoracic part of the œsophagus they can be forced down into the stomach, for which purpose Petit's probang (Repoussoir) is useful. This consists of an elastic staff which carries a sponge at one end. Thick œsophagus sounds are equally useful for this purpose; while elastic (whalebone) staffs armed with a metal ball as large as a cherry are much more practical than the repoussoir and sounds, because they furnish a means of more delicate touch of the foreign body and better indications for the force to be employed in projecting them onward (von Langenbeck*).

The removal of foreign bodies from the œsophagus can also be made by opening it, that is, by œsophagotomy. This is called for as a direct life-saving operation in cases where foreign bodies are present which cannot or may not be pushed or extracted; thus in all voluminous, but not

* V. Langenbeck, Ueber d. Fremdkörper im Œsophagus u. über de Œsophagotomy. Berl. Klin. Wochenschr. 1877, Nos. 51 and 52.

compressible objects with irregular, sharp edges or rough surfaces, for instance, artificial teeth. Efforts to push such bodies upwards or downwards in the œsophagus might be followed by injuries to the œsophageal mucous membrane, tearing of its walls, and even by rupturing neighboring organs (the trachea, aorta) with extrusion of decomposing elementary masses into the mediastinum or into the lungs, or by fatal hemorrhage of the aorta. These consequences would also occur as results of ulcerative processess, in case such foreign bodies were left in situ. Therefore the removal of such foreign bodies is imperative, at all hazards.

Further indications for œsophagotomy are inoperable tumors in the cervical part of the œsophagus, completely plugging it, and, thirdly, non-dilatable strictures in the cervical œsophagus. Furthermore, œsophagotomy has been performed in impermeable strictures in the thoracic œsophagus for the purpose of endeavoring to dilate it gradually through the wound (Bryk*). This suggests the use of bougies in strictures which appear impermeable in the cervical part, passing said instruments through the wound upwards.

The directions of the incision in œsophagotomy are the same as in ligation of the common carotid artery. The incision is made either at the level of the thyroid cartilage, at the inner margin of the sterno-cleido-mastoid (Guattani, Cooper, Bell, Boyer, Richerand) and the omo-hyoid is drawn either upwards or downwards. Or the operation is made in the trigone of the sterno-cleido-mastoid, at the base of the neck, principally when a foreign body is lodged deeply in the thoracic part of the œsophagus with the first-named incision after dividing the skin, the platysma and the superficial cervical fascia, requires the exposure of the inner margin of the sterno-cleido-mastoid, laying bare the vascular sheath, which is not to be opened. At the outer side of the sterno-hyoid and under the deep cervical fascia we find the œsophagus. Owing to the more superficial position of the œsophagus on the left side, *the operation is always made on the left side.* Usually the walls of the œsophagus are found dilated by the foreign body, and when the foreign body lies still deeper the œsophageal wall is forced outward by the projecting staff of the EKTROPŒSOPHAGUS (Vácca Berlingheri). A bent metal catheter or a lithotomy sound or an

* Bryk, Wiener Med. Wochenschr. 1877, Nos. 40 to 45.

œsophageal sound armed with a mandrin, inserted through the mouth, may be used instead of the before-mentioned instruments.

If it is desired to maintain the œsophageal wound open for any length of time, the lips of the wound in the mucous membrane are sewed to those of the skin and nutrition must take place through œsophageal catheters. If the mucous lips are not sewed to the skin, inflammatory infiltrations and formations of pus into the connective tissue around the œsophagus easily occur. If œsophagotomy has been performed only for the removal of foreign bodies, the wound in the œsophagus may be closed directly by sutures. The wound in the tissues should also be sewn up, but a drainage-tube, directed downwards, left in the wound.

Foreign bodies, whose pressure upon the trachea produces acute asphyxia, must not be removed before respiration has become thoroughly free. In such cases we must follow the old principle and first execute tracheotomy. After this the foreign body may be removed through the mouth or through the wound in the œsophagus.

Tumors of the œsophagus, situated in the cervical part and circumscribed to the walls of the œsophagus, such as circumscribed epithelioma, are to be removed by resection of the œsophagus. Tumors developed in the thoracic part are inoperable. When they have affected the œsophageal walls in an annular shape they result in strictures, which finally allow food to pass only with great difficulty or not at all. In these cases opening the stomach in the epigastrium appears the only saving means to prevent death from starvation. We will consider gastrotomy, although the carcinomatous stricture may still be permeable when the passage of food or the passage of the œsophageal sound through the stricture furthers the destruction or stimulates a more rapid growth of the tumor.

Tumors occur, for instance, above the cardia, which involve only the walls of the œsophagus. Pain and narrowing of the œsophagus may be absent and the tumors discovered only post mortem. Ofttimes numerous metastases are found, especially in the liver (the œsophageal veins communicate directly with the portal circulation).

Strictures of the œsophagus are found, as has been said, most frequently at the same sites of election as are foreign bodies and tumors. They are either of traumatic nature, occurring after direct injuries of the œsophagus, or we see

them formed as a result of cauterizing after shedding of the slough produced by the cauterization (swallowing sulphuric acid or strong alkalies.) Diphtheritic processes also may leave loss of substance, which by cicatricial contractions may produce stenosis in the œsophagus. Similar results obtain after chronic inflammatory processes of the œsophageal mucous membrane, which appears hypertrophic, and thickened thereby. Spasmodic or hysterical strictures have been observed, but these, as is natural, cede to the administration of chloroform. Finally, as we have seen, a narrowing of the œsophagus is possible from annular tumefaction within it, and also by pressure exercised upon the œsophagus from without, as in retro-pharyngeal abscesses, aneurism of the arch of the aorta, carcinoma of the spinal column, sarcoma of the mediastinal lymph-glands, etc.

Permeable strictures of traumatic origin are amenable to gradual dilatation with sounds. The introduction of sounds is made mainly through the mouth. It is only exceptionally that strictures in the thoracic portion can be dilated exclusively by inserting the œsophageal sound through the opening in the œsophagus made in the neck.

The introduction of elastic tubes through the œsophagus is required when we desire to introduce alimentary substances directly into the stomach, as in difficulties of deglutition, such as occur after resection of the upper or lower jaw, in acute tonsillary angina and in rapidly growing pharyngeal abscesses. It is also required in the insane who refuse to take food. When these patients will not open their mouths, the œsophageal catheter is either introduced through the nose or the patient is chloroformed and the tube inserted through his mouth. To avoid inserting the œsophageal catheter into the trachea, which would be followed by the introduction of alimentary liquids into the respiratory tract, the patient is narcotized and a gag placed between his teeth. Then the patient is allowed to recover from the narcosis and the thickest œsophageal sound is inserted through the orifice in the gag down to the stomach (Roser.) The larger the sound selected, the safer is the avoidance of inserting it into the trachea. Previous to pouring in alimentary liquids a few drops of water are allowed to run into the catheter, which will certainly produce reflex coughing in case the sound has been inserted into the trachea.

The introduction of the œsophageal sound is most easily

done when the patient is sitting, His head is held as far back as possible, causing the free edge of the upper incisor teeth to form a tangent to a line projected from the axis of the œsophagus (Trendelenburg).* The index finger of the left hand—which, when the patient is a child or insane, should be protected with a metal case—is laid upon the tongue as far as the epiglottis. The tongue is pressed downwards and the catheter is inserted over it to the posterior wall of the fauces. As in catheterizing the urethra the symphysis is the key to guide the instrument out of the membranous portion into the neck of the bladder, so in the introduction of œsophageal catheters or bougies, *the anterior surface of the spinal column against which the posterior faucial wall lies, is the guide.* If the patient is caused to swallow when the instrument passes the entrance of the trachea, and thus elevate the trachea, and close the epiglottis over it, the entrance of the instrument into the air-passages is more surely avoided.

When great restlessness or excessive sensibility compels us to catheterize the œsophagus in the narcotic state, Girard's † process is recommendable. It consists in narcotizing the patient in the horizontal position and to have his head fixed by an assistant, as it hangs over the edge of the table so as to cause the margin of the upper incisors to form a tangent to the longitudinal axis of the œsophagus. The operator stands at the left shoulder of the patient and can guide the straight instrument horizontally into the œsophagus while holding it in his supine hand and employing delicate tact. Many advantages may be claimed for Girard's method in dilating strictures with bougies, the removal of foreign bodies, and for endoscopic examination of the œsophagus and the interior of the stomach.

We shall now proceed to the consideration of those impediments which may disturb the progress of the intestinal contents within the small and large intestine. The principal matter with which we have to deal is strangulated hernia.

As you know, gentleman, we distinguish reducible, or mobile, adherent and incarcerated hernias, and under ther-

* Treudelenburg, Zur Extraction v. Fremdkorpern aus dem Œsophagus. v. Langenbeck's Archiv, 1872, Bd. xiv. p. 63.

† Girard, Zur Anwendung d. Narkose b. Untersuchungen d. Œsophagus, Centralbl. f. Chirurg., 1880, No. 21, p. 337.

apeutic measures we discuss reposition, retention, and radical cure. The treatment of incarcerated hernias pertains to the domain of urgent life-saving operation.

You, furthermore, know that in hernia we must consider:

1. *The orifice of the hernial sac*, through which the hernial tumor escapes. These orifices are either dilated normal openings in the abdominal walls (crural rings, inguinal canal, umbilicus), or abnormal slits in any of the ventral walls (diaphragmatic, ventral, perineal hernias), or abnormal slits brought about by folding, bending or twisting of the mesentery and the intestines themselves. In this sense intussusception and ileus belong in this category.

2. *As to the hernial contents.* All of the abdominal organs may be found in a hernia. However, most frequent are hernias of the gut or peritoneum (enterocele and epiplocele) or both together.

3. You know that by *hernial sac* we mean a procidentia of the peritoneum generally involving the contents of the hernia.

The peritoneal covering may be absent, (*a*) in vesical hernias, when the bladder proceeds directly out of Retzius's prevesical space through the subcutaneous inguinal ring, or (*b*) when the cœcum, the posterior side of which is not covered by peritoneum, forms the contents of the hernia. Finally (*c*), in many umbilical hernias, perhaps because of atrophy of the peritoneal pocket, and (*d*) in hernias of the umbilical cord. The absence of peritoneal covering can furthermore depend on a rupture of the hernial sac, or an escape of the ventral contents beneath the skin, after subcutaneous tearing of the abdominal walls.

The *hernial neck* is especially important; it is created by coalescence of the folds of the hernial sac, which have been formed in the hernial opening. It can also be pushed upwards or downwards from the hernial opening. If the neck of the hernia be obliterated after replacing or reducing the hernia, a hernial cyst may form (probably certain femoral cysts below Poupart's ligament may be considered as pertaining to this class).

Hernias which are not invaginated, may be irreducible either because of the large mass of intestine—large scrotal, umbilical, or ventral hernias,—or through adhesion of the hernial contents with the sac, or neighboring organs, for instance, within the scrotum, as in congenital inguinal hernial.

Both of these causes for the irreducibility of hernias may often be set aside by continuous efforts at taxis (Arnaud, Hey, Malgaigne), for five or six weeks, sometimes success results within eight to fourteen days, during which compression with lead plates, or with elastic bandages, has been employed during the intervals between each séance. Irreducible large hernias have become reducible spontaneously after emaciation following acute diseases.

The third cause for the irreducibility is found in incarceration. We observe four elements to it:

1. Inflammatory swellings of the surroundings of the hernial opening, or within it near the rupture—inflammation in the region of the spermatic cord in external inguinal hernia. It is very rare.

2. Fœcal filling of the hernial contents: incarceratio stercoralis—Engoûement.

3. The occurrence of a sudden disproportion between the hernial contents and the neck, especially when the latter has been subject to fibrous thickening by prolonged wearing of a truss, and the intestinal loop has been forced into the hernial sac which formerly was empty, then real strangulation occurs. The disproportion between the intestine and the hernial neck—in these cases *the intestinal loop is often found quite empty*,—is caused by continued increase in volume of the hernial loop in consequence of circulatory disturbances in the intestinal walls. These are most frequently of a venous character. The disturbances may be quite insignificant in the beginning (Borgreve's experiments). An example thereof might be made of a metal ring which can be pushed on the finger easily; but soon œdematous swelling of the finger takes place and the removal of the ring is rendered difficult, often entirely impossible.

4. Fibrous bands in the lumen of the hernial sac, in which the intestinal loop may be doubled upon itself, or wedged in.

The dangers of invagination are in proportion to its degree and rapidity of the damming of the circulation in the intestinal loop. When circulation is suddenly and totally interrupted, as in compression of the veins and arteries, the intestinal loop collapses, becomes anæmic, discolored, gangrenous (anæmic gangrene, Roser,*). In such cases efforts at taxis will be found useless, and only

* Roser, Centralbl. f. Chir., 1879, No. 40.

rapid operative measures will save the loop from death. Relieving invagination in these cases has quite justly been compared to cutting the rope in hanging.

*The symptoms of acute invagination* are very violent. Intense pains are felt while the swelling in the region of the hernial tumor is not great. The hernial tumor may soon show a doughy, emphysematous consistence, caused by a development of gas in it.

The less violent course of invagination, which we will designate as the *subacute form*, is found in such cases where the impediments to circulation are produced more slowly. The veins as they lie more superficially are compressed first. Therefore, co-incident with circumscribed venous stasis an increasing œdema of the intestinal loop presents itself, then transudation into the hernial sac and as a consequence of the stasis extrusion of red blood-corpuscles into the tissues of the intestinal walls, all producing real capillary and larger extravasations of blood. In these cases the loop does not appear steel-blue or grayish, as in the previous class, but dark red in the beginning, and later brownish-red. Inasmuch as the arterial supply is not entirely interrupted, despite the venous stasis the danger of gangrene is not so great and often is delayed for several days. Therefore in these cases taxis promises better results.

The processes which we have designated as characteristic of invagination cannot be presented schematically better than by Cohnheim's* original experiments on temporary interruptions of the venous and arterial circulations in the frog's tongue. Microscopic observations of the occurrences which take place in the tissues of the tongue are so significant that if you wish to inform yourselves upon the changes which a hernial loop suffers on invagination, I cannot too urgently recommend you to a study of the above experiments.

In general, the symptoms will be more violent the more acute the strangulation, as is shown by the intensity of the pains and general collapse. Stercoraceous vomiting is often absent in a rapid course of the affection but in general it presents itself the sooner, the nearer the invaginated intestinal loop is to the stomach.

Real strangulations must be distinguished from ap-

* Cohnheim, Neue Untersuchungen über d. Entzündungen, Berlin, 1873, and Vorlesungen ü. allgem. Pathologie, Bd. i., pp. 108 to 133.

parent ones, that is, those in which the series of symptoms which resemble those of strangulation are dependent upon other causes.

Thus we find (*a*) *peritonitis within the hernial sac.* It may occur after traumatism to any empty hernial sac. Or they may be developed when the projecting intestinal loop suffers perforations of its wall by foreign bodies or ulcerations. Furthermore (*b*) in this connection must be considered *inflammation of a serous membrane adherent within the hernial sac* (so-called inflammatory invagination); and then (*c*) *spasmodic invagination.* This refers to spasmodic anti-peristaltic motion of intestinal loops in atony of the intestine, or may depend upon tension on the mesentery in large adherent ruptures. Finally, we will mention (*d*) *intussusception*, which may occur within the abdomen, as also within a hernia.

Omitting the treatment of apparent strangulation, we would employ antiphlogistic means in peritonitis of the hernial sac as well as in inflammatory epiplocele accreta. When an abscess forms, especially in intra-hernial peritonitis, opening the abscess becomes necessary. In intestinal colics we would have to employ the wet pack, clysters of opium and purgatives. In intussusception laparotomy may be thought of in case the intussusception occurs within the abdomen. But if symptoms of intussusception are accompanied by peritonitis in the hernial sac, we will have to proceed to an exploratory herniotomy. This applies to cases where the symptoms of strangulation occur with multiple irreducible hernias.

Before we proceed to the treatment of hernial strangulation we will first call to our minds the place or site where it may occur. In recent hernias the hernial opening itself may be the contracting point, and this opening may appear as a ring (crural ring), or as a canal (inguinal canal), or as a split in the abdominal coverings. In old hernias, especially where a truss has been worn for a long time, the seat of the strangulation generally takes place in the fibrous thickened neck of the sac, which, as we have seen, may sometimes be above and sometimes below the hernial opening. Thirdly, the strangulation may occur neither through the hernial opening nor the neck, but through neoplastic bands within the hernial sac itself, or produced by an intestinal loop being caught in an opening of the peritoneal net. The net also, in an epiplocele, when it has been converted into a pear-shaped polypoid tumor, may produce strangulation

when it is withdrawn towards the hernial opening. As it becomes wedged in there, it presses upon the gut between itself and the hernial opening.

*The treatment of strangulated hernia* implies the essential principles that are suggested by acute interruptions of circulation in the intestine in recent ruptures with violent pains, rapid collapse, etc., (strangulated loop). *The only life saving means is herniotomy executed as soon as possible.* In less acute strangulations the mechanism is to be considered, and taxis first employed.

Three manipulations are to be distinguished in taxis, according to the mechanism of the strangulation. In case taxis does not succeed immediately, the success may be attained in repeating the manipulations under the influence of an anæsthetic:

(*a*) The mechanism, according to Lossen,* applies especially to fœcal impaction and is brought about in the manner that I will show you. If a loop of intestine be made to traverse a hole bored through a plank, which hole is somewhat smaller in diameter than the part of the loop which enters it and if you force into the intestine any substance which in consistence resembles the fœcal mass (as boiled peas or grits), a moment will arrive when the mass can no more be forced into the part of the loop below the opening in the board. Close examination will show you that the lumen of the afferent loop within the artificial hernial rupture is completely choked and pressed against the wall, while the lumen of the efferent part is filled entirely with the above-named pap. The mechanism, according to Lossen, consists of the sudden filling of the afferent part of the intestine with tough matters which it is difficult to move, so that the ring of the hernial opening is completely occupied by it and the walls of the efferent part of the gut are so pressed together that the progress of its contents is prevented. If we reduce the diameter of the afferent part of the intestine within the hernial opening then the intestinal contents can extend the efferent part and thus make their way

* Lossen, Studien u. Experimente ü. d. Mechanismus d. Brucheinklemmung, Verhandl. d. iii. Congress. d. Deutsch. Gesellsch. f. Chirurg., 1874, and v. Langenbeck's Archiv. B. xvii., p. 301. Compare excellent articles by Busch, Lossen, Roser in Centralblatt f. Chir., 1874. and by Bidder, Kocher, Lossen, and Roser in same journal 1875, as well as Grossere Vorträge, by Busch, Lossen, and Roser in the Verhandl. d. iv. Congr. d. Deutsch. Gesellsch. fr. Chir. im Jahre, 1875.

out of it. To bring about the same results in a real hernia with fæcal impaction, we must exercise pressure upon the afferent intestine within the hernial opening. This pressure must be made radially, from the side of the choked afferent intestine to the opposite point of the circle of the hernial opening. Inasmuch as we cannot tell at what place the afferent gut is compressed during life, therefore we will have to compress the afferent gut within the hernial opening towards all sides radially, until the pressure upon the tensely filled hernial tumor produces free motion of its contents and thus relieves the fæcal impaction.

According to Roser,* the impaction is brought about by a lack of proportion between the loop and the neck of the hernia, which results in the formation of longitudinal folds in the intestinal walls, within the hernial neck, whereby a flap-like mechanism is produced which when the base of the hernial tumor is pressed upon causes complete shutting off of the intestinal contents from the intestinal tube above the hernial neck. In order that reduction may succeed, simple pressure from the base of the hernial tumor in the direction of the hernial opening must not be exercised, as thereby the form of the tumor will be converted from that of a pear-shaped long-necked bottle into that of a flask which has been flattened in its longitudinal axis. But we must compress the hernial tumor with the fingers of one hand closely beneath the hernial opening, while we grasp the tumor with the other hand and endeavor to conduct its elongated form back through the neck of the hernial tumor (Streubel †).

(*c*) Busch ‡ holds that we must picture impaction of an intestinal loop thus: repletion of the intestine extends its free outer wall, more than its inner one, and the mesentery becomes adherent, thus a doubling of the afferent as well as efferent gut is produced within the hernial orifice, preventing further passage of the intestinal contents to the intestine beyond the hernial tumor. The passage is only made possible by relieving the doubling within the hernial orifice in bending the hernial tumor in the opposite direction, thus

* Roser, Archiv. f. physiol., Heilkunde 1856, 1857, 1860 and 1864. Compare also Roser's Handb. der Anat., Chir., 1872, p. 343.

† Streubel, Prager Vierteljahrschr., 1861, Bd. 1, p. 1.

‡ Busch, Sitzungsberichte d. Niederrhein. arztl. Gesellschr. v, 10, Marz., 1863.

straightening the axes of both the efferent and the afferent intestines.

Besides narcosis, certain positions of the lower extremities facilitate taxis; flexion and adduction of the thighs relax the abdominal walls and reduce the tension of the inguinal canal. In crural hernias coincident rotation of the thighs inwards favors a relaxation of the fascia lata. Elevation of the coccyx acts by allowing the intestines to fall back against the diaphragm and by the traction which the mesentery is thus caused to make upon the hernial loop. In like manner deep inspirations, lying on the healthy side and perhaps also a knee-elbow position, exert their influence. Those adjuvants to taxis which were formerly recommended, as, bleeding, leeches, the warm bath, extensive cupping of the abdomen, warm fomentations, narcotics, (opium, belladonna) etc., have been entirely substituted by chloroform (or ether) narcosis. The administration of purges, clysters, tobacco (inf. fol. nicot. [5.0] 200,0; gummi mimos, 10,0 ol. ricini 15, 0; M. D. S. for two injections) the ice bag, direct compression of the hernial tumor (elastic compress), have yielded favorable results only in isolated cases, and *then* owing to particularly favorable circumstances. Results should sooner be expected from forcible injection or pouring of water into the rectum, as in ileus.

When taxis is properly made under the influence of an anæsthetic we will not hesitate to proceed immediately to herniotomy, utilizing the existing narcosis and having made all preparations before. We will now occupy our attention with the details of this operation.

1. We must consider the cases wherein apparently successful taxis makes herniotomy become necessary. Spurious reduction, apparent reduction, false reduction (Streubel*) occurs upon returning the hernial loop *en bloc* with its sack in strangulation, above the hernial orifice between the abdominal parietes and the peritoneum parietale. A similar occurrence can take place after opening the hernial sack in herniotomy when the hernial walls are not fixed during reposition of the loop. Then the gut may be forced through the dilated hernial neck into the abdominal cavity beside the neck, and between the peritoneum and abdominal wall.

2. By annular tearing of the constringent hernial neck,

* Streubel, Ueber d. Scheinreductionen b. Hernien, Leipzig, 1864.

which is pushed into the abdominal cavity with the hernial tumor.

3. By returning the prolapsed intestinal loop without relieving its torsion or invagination.

*Herniotomy*, the operation for relief of intestinal strangulation, has saved more human lives than have all other means which have been recommended or adopted for their relief; notwithstanding that the proximity of the abdominal cavity made this measure always appear one which required serious consideration, previous to the period of the antiseptic treatment of wounds.

Herniotomy, as well as lithotomy, is said to have been first recommended in the middle of the sixteenth century (Franco *); Ambroise Paré † often performed it successfully. Special instruments are not at all requisite for this operation; the necessary instruments are found in every operating case.

The strangulated loop is exposed by splitting the soft parts which lie upon it according to the rules which were learned for isolating the larger vessels and for opening the trachea.

We first incise the skin in the direction of the long diameter of the hernial tumor. In femoral hernia this would imply an incision parallel to the axis of the femur, while inguinal hernias require an incision parallel to Poupart's ligament which will have to extend to the scrotum in the male or the labium maj. in the female. An exception thereto is made in strangulated umbilical hernias, which preclude opening the hernial tumor at its apex, because of the thinness of its coverings. According to the maxims which have been already enunciated, an incision is made either in the linea alba or in a direct parallel to the base of the hernia and near it (preferably to the left). Then the umbilical ring is freed and notched, as is the hernial neck within it, so as to permit the extraction of the intestinal loop from the hernial sack after separation of its adhesions. The other hand supports the region by compression of the hernial tumor from without (Dieffenbach ‡). The further treatment of the wound is similar to that of laparotomy.

In all other stranglated hernias after splitting the skin, the sub-adjacent tissues must be separated with a knife for

* Franco, Traité des hernies, Lyon, 1561.
† Ambroise Paré, Œuvres complètes; ed. Malgaigne, Paris, 1840.
‡ Dieffenbach, Operative Chirurgie. Bd. ii., p. 612.

which purpose they are elevated singly with two rat-toothed forceps as thin plates of connective tissue. Formerly it was customary to drill the several connective tissue layers apart with a hollow sound, but this practice is decidedly reprehensible.

The impediments to circulation in the hernial loop are followed by the transudation of a fluid into the sack (Bruchwasser). The escape of this fluid is the most reliable sign in many cases that we have opened the hernial sack. But in œdema of the hernial sack-walls, fluids may also be found between the separated layers. Again, it may happen that there is no hernial fluid (Bruchwasser) which occurs especially in crural hernias and markedly so in very acute strangulations or also in cases which progress very slowly (hernia sicca). In the latter cases adhesions are often found between the intestinal loop and the hernial sack. Then great care is required in our procedures, lest the gut be split.

In former times the question was discussed whether hernias could be relieved, especially in cases of recent strangulation, without opening the hernial sack (external herniotomy.) It was proposed to free the hernia with its sack from the site of contraction by incision, tearing or separation with the fingers. This procedure does not appear reliable; as, first, the strangulation happens frequently within the hernial sack and then, above all, the method allows no view of the intestine. The other advantages which are claimed for external herniotomy have lost weight since the introduction of antisepsis.

Therefore it is more advantageous to free the intestinal loop by *opening the hernial sac and relieving the strangulation directly* (internal herniotomy). For this purpose a probe-pointed somewhat curved knife, with a concave cutting edge, like a bistoury of the ordinary pocket-case, is used. Special herniotomes are mentioned and called after known surgeons (Pott, A. Cooper, Rust, Seiler, and Tesse. The knives of the latter have convex cutting edges. Grzymala has devised a cover for the point of a convex knife.)

To enlarge the site of constriction *the knife must not be drawn, but allowed to act by pressure.* It is introduced into the contracted site, lying flatly upon the index finger, the cutting edge is then erected against the constricting ring, and by pressure of the finger upon the blade it is made to notch the ring at various places in a centrifugal direction (Vidal's débridement multiple). For this purpose the her-

niotome need be sharp at its free end only as is Cooper's bistoury, which may be improvised by wrapping the greater part of the blade of a Pott's knife with adhesive plaster. Multiple-notching for the relief of the constriction is highly advantageous over unilateral incision (Pott, Garangcot), which requires special care in inguinal hernias to avoid wounding the epigastric artery. If Gimbernat's ligament were split towards the symphysis there would be danger of wounding the obturator artery in case the latter should take an abnormal course from the epigastric around the crural ring descending to the obturator foramen (Todtenring, death-ring). But the possibility of wounding this artery has been very much exaggerated, and has detained many from performing herniotomy. Thus Dieffenbach is perfectly right in saying that the fear of wounding an abnormal epigastric artery has cost more human lives than the injury itself (Operat. Chirurgie, Band II., p. 480.)

The second step of herniotomy, the multiple-notching of the contracted part of the hernial opening or sack, frees the contents of the hernia from constriction. And now the third step, the *reposition of the hernial contents* will be considered.

The freed intestinal loop should never be returned to the abdominal cavity without first drawing it forth, to assure us that there is no further site of contraction higher up in the hernial sack. Secondly, we must *assure ourselves of the condition of the loop*, especially at those places which have been subject to direct constriction, and which have often been left with gangrenous marks as the result of pressure. If the loop is quite healthy, such adhesions as may exist should be broken up, and then the loop returned in such a manner *that that part of the intestine which prolapsed last is returned first.* Old adhesions which are separable with difficulty, or not at all, notwithstanding the relief from constriction, will oblige us to return the intestine in the old position. If the appearance of the loop is not normal, all those manifestations which we have described in sudden or slow interruptions of the venous and arterial circulation in the intestinal canal, must be considered in the interests of prognosis. Then Cohnheim's experiments on the tongue may serve as examples. It will be especially difficult to decide whether a discolored spot in the intestinal walls will return to a normal condition or will suffer mortification. In this sense many fatal errors have been committed.

If a part of the intestine is really gangrenous, or if a perforation has occurred, our subsequent treatment has a more distinct base. In round, hole-shaped perforations it has been proposed to draw forth the affected part of the intestine with a forceps, and to place a ligature about the base of the cone thus drawn forth, just as Cooper proposed in hole-shaped injuries to the larger venous branches. Linear necroses of the intestinal wall are most frequently diagonal to and sometimes at an angle to the intestinal canal, and corresponding to the contracting ring. In such cases the dead parts may be excised and the lips of the wound drawn together by button-sutures or by continuous suture in such a manner that the serous surface of the lips of the wound are brought in exact opposition, and the mucous margins are turned over to project into the intestinal lumen (Lembert's suture).

The same principles guide our application of sutures when an entire loop of intestine has become gangrenous, and we wish to unite the upper stump of the amputated gut with that which was below the contraction. The safest course in these cases is that laid down by Kocher's excellent advice. Beyond all, not only must the gangrenous loop be excised, but also so much of the neighboring part of the gut as may appear suspicious—that is, discolored brownish or blackish red, swollen, or covered with fragile dim serous membrane, or filled with mucus of a bloody tinge, or, in a word, so much must be removed as appears infarcted. The infarction depends on a venous stasis within the intestinal walls that have been tensely stretched in the strangulation. This stretching almost always affects the afferent gut. The resection of the part of intestine which is to be removed is begun by notching the constricting ring as much as possible, so as to be able to draw forth the intestine easily. Large clamps, or, in emergencies, temporary ligatures, are made to close the upper and lower boundaries of the dead parts. These should be applied to healthy intestine. At the same time fixed ligatures are made to secure both ends of the piece of intestine which is to be excised, and a strong silk thread is tied around the mesenteric fold which pertains to the necrotic loop. Then the scissors are used to excise the necrotic gut between two ligatures, or between

* Kocher, Zur Methode d. Darmresection b. eingeklemmter gangranoser Hernie. Centralblatt f. Chir., 1880, No. 29.

ligature and clamp, taking great care not to soil any of the parts with the contents of the healthy intestine, nor with gangrenous bits, and particularly to avoid the entrance of either into the abdominal cavity. Finally, the excised piece is separated from its mesentery, which has been ligated.

Then threads are drawn through the intestinal stumps beyond both clamps, which threads are to be used for the application of Lembert's suture. The stitches are run through the intestinal wall parallel to its serous surface in such a manner that they do not penetrate anywhere into the intestinal lumen. Previous to tying the sutures, those parts of the intestinal stumps which have been clamped or tied are cut off with the scissors, between the clamp and line of suture, or between the temporary ligature and line of suture. It is also recommendable to allow the contents of the upper part of the intestine, which are mostly mixed with blood, to run into a dish previous to tying the threads. Besides the deep sutures, smaller superficial peritoneal sutures, which grasp only serous membrane, must be placed between them. After complete disinfection, the intestine which has been restored, by suture, is to be returned. Tension on the line of suture is best avoided on reposition, as has been mentioned, by thoroughly notching the contracted site of the hernial sac. In all cases the double suture must be made carefully and closely, *especially in the vicinity of the mesenteric insertion*, to insure that the intestinal contents will nowhere escape between the stitches. Kocher recommends opium in the after-treatment, but attaches more importance to the emptying of the upper intestinal stump previous to suture, as has been cited, as well as subsequently washing out the stomach with borated water, so as to disencumber the sewed intestine entirely. During the ten days following the patient must swallow nothing but small pieces of ice. Nutrition is carried on by injections into the rectum.

Enteroraphy, after resection of a gangrenous gut, is the simplest and safest procedure, which will seldom disappoint in recent cases, when skillfully executed. Resections of the gut, followed by enteroraphy, should substitute all other measures for the treatment of gangrenous hernias.*

* It has been shown experimentally that long intestinal loops can be removed from their continuity of the intestinal tube, so that they re-

When the greater part of the circumference of an intestinal loop is necrosed and the restoration of its lumen is impossible, and where an entire resection of the affected intestinal piece is not made, the necrotic gut has occasionally been simply incised and fixed in the wound with a few stitches. It is self-evident that this operation must be followed by an artificial anus.

If it be decided to cure this subsequently by an enteroraphy, other conditions than those incidental to a primary resection of a gangrenous loop prevail. After the point of attachment of both intestinal stumps in the abdominal wall has been split or circumcised and the intestinal stumps separated from the abdominal fistula and their margins refreshed diagonally, the upper intestinal end, which generally is the only one in function, appears dilated, while the lower one is callapsed and much narrower than normally. The dilatation of the upper intestinal tube which terminates in the abdominal fistula, will appear greater in proportion to the amount of contraction which has occurred in the mouth of the fistula. When considerable incongruity was found in the sizes of the intestinal stumps the larger intestine which was folded over, or an edge thereof was placed within the lumen of the narrower, which had been cut through diagonally, and then Lembert's suture applied, as usual, after the tube was also fastened by sutures within the smaller intestine (Billroth*, Czerny). Or, as was advised by Jobert, the wider intestinal tube was folded in upon itself while the narrow one was simply pushed into the other one. Complicated propositions, such as for instance, Denan's suture with three cylinders pushed into the intestine, are worthless.

The principles for the treatment of a rupture after relief of the constriction, are somewhat modified when the rupture contains peritoneum only or peritoneum and intestine, normal and healthy peritoneum may be simply replaced like normal gut. Peritoneum that is adherent to the hernial

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main connected only with the mesentery. If then the lumen of the removed piece is thoroughly washed with five-per-cent carbolic-acid solution, the piece of gut with its two open ends may be replaced within the ventral walls without evil consequences. Of course the two intestinal stumps must be brought together to restore the continuity of the intestine.

* Billroth, Ueber Enteroraphie. Wiener Med. Wochenschrift, 1879, No. 1.

orifice is soon permeated by granulations, and finally shrinks, while it often yields a good permanent closure of the hernial opening. Parts of hypretrophic, degenerated peritoneum which have become converted to a rolled-up lump of connective tissue, should be excised after the stem of the epiplocele has been ligated *en masse* or when this stem is extraordinarily thick, after its vessels have been provided with ligatures. Those convulsive and inflammatory manifestations which formerly followed this ligature *en masse* (symptoms of strangulation, vomiting, and sub-serous phlegmons) are to be attributed to defective treatment of the wound and not as a consequence of traumatic irritation by the ligature *en masse*.

The after-treatment of herniotomies, in which antiseptic measures have been strictly followed, after reposition of the intestine, the wound of the skin may be sewed subsequent to the insertion of a drainage tube into the hernial sack. It appears far more appropriate after reposition of the hernia, to isolate the neck and to draw it up as high as possible against the abdomen with a stout thread which has been boiled in a five-per-cent carbolic solution and to remove the sack *in toto* from its surroundings below the constriction. This method of *radical cure* of hernia which can be executed in most of those which have been strangulated and reduced by operation, has been resuscitated recently under the protection of Lister's treatment, while in the past it had been known and practiced, yet desisted from owing to its dangers. The radical treatment of hernias in the recent antiseptic period, are especially discussed in the works of Czerny*, Risel †, Schede ‡, Maas §, and Steffen ‖.

In inguinal hernias, after ligation of the neck, the hernial opening is closed with special sutures (Czerny's corset sutures or also the mattress suture). The cases which until now have been operated upon, according to the above method with antiseptic precautions, have yielded very favorable results as regards life. The rupture itself is to

* Czerny. Studien zur Radicalbehandlung d. Hernien. Wiener Med. Wochenschr., 1887, Nos. 21 to 24.

† Riesel, Deutsche Med. Wochenschr., 1877, Nos. 38 and 39.

‡ Schede, Centrabl. f. Chir., 1877, No. 44.

§ Maas, Ueber Endresultate radicaler Hernienoperationen. Breslauer arztl. Zeitschr., 1879, Nos. 5 and 6.

‖ Steffen (Socin's Klinik), Ueber Radicaloperation d. Hernien. Basel Franz. Diss. 1879.

be considered as cured in many cases as soon as the patients can follow a part of their occupations without a truss. Partly, at least, so much was attained that ruptures which previous to the operation could not be contained by a truss, permitted one to be worn thereafter. How long this condition lasts, whether the cure remains definite or whether relapses would notwithstanding occur upon discarding the truss, are questions which cannot be definitely answered as yet, owing to the brevity of time which has been devoted thus far to these operations.

If no radical cure has been attempted, the patient is allowed to rise after the wound is healed and to exchange his antiseptic compress-bandage for a truss.

But when a gangrenous rupture has been treated, where the formation of an artificial anus is inevitable, the fæces will cover the wound permanently and prevent its antiseptic treatment. Then the wound must be simply left open or covered with disinfecting dressings (carbolized or salicylated oil compresses) and unimpeded evacuation of the excrements as well as the secretions from the wound must be provided. The subsequent relief for unnatural anus has been briefly discussed above.

## LECTURE IX.

GASTROTOMY.—*Indications.—History.—Spontaneous gastric fistulæ.—Sites for opening the stomach.—Fixation into the abdominal wall.—Attaching the abdominal wound with the gastric mucous membrane.—Drainage-tube.—Obturators.—Condition of the patient in gastric fistula.—Artificial (external) œsophagus.*—OPENING THE DUODENUM.—*Closing gastric Fistulæ.*—ANOMALOUS ANUS.—ATRESIA ANI.—DEGREES OF DEFECTUS ANI ET RECTI.—*Opening atresic anus.—Lumbocolotomy.—Laparocolotomy.—Fistula of small intestines.*—ARTIFICIAL ANUS.—FOREIGN BODIES IN THE RECTUM AND IN THE VAGINA.

While œsophagotomy permits the introduction of food through a wound made into the œsophagus, when an impermeable stricture about the level of the larynx occludes it, deeper impediments for the passage of food as are all impermeable strictures, that is, those which even in narcosis are intransitable, in the thoracic part of the œsophagus, will require direct introduction of food into the stomach through a wound of that organ, as the only means by which to save the affected individuals from death by starvation.

Gastrotomy* is not only indicated in the above cited cases where entire stenosis of the œsophagus, or, at least, nondilatable centrifugal strictures, as a consequence of ulceration or cauterization, of acids or alkalies occurs, but also in those strictures which are still permeable when they depend upon the growth of tumors (cancers) in the œsophageal walls. Here, as in rectal carcinoma (Curling), to permanently remove the irritation of the tumefied masses, such as is brought about by the frequent introduction of instruments

* Many choose to speak of *Gastrostomy*, or the opening of a gastric fistula, in distinction to *Gastrotomy*, incision of the stomach. Gastrotomy would mean only temporary opening of the stomach; but gastrostomy was to apply to a permanent opening for continuous nutrition. We consider these distinctions as superfluous and confusing, and will retain only the term gastrotomy. The term gastrotomy as a designation for abdominal incision (laparotomy) is frequently abused in England and Italy.

for the purpose of dilation and nutrition, gastrotomy is undertaken, and thus the danger of disintegration of the tumor is avoided (Billroth*). A further indication for opening the stomach is when substances are swallowed whose dimensions preclude their passage through the intestinal canal. Among these may be considered forks and knives, which frequently have given cause for direct opening of the stomach. Also needles may require it. It is safe to say that they but very rarely penetrate the gastric walls, thence to take up their migrations through the organism. Most of them probably remain in the stomach or intestines, become imbedded in the mucous membrane, or when unfavorable circumstances prevail cause an abscess in the gastric walls which penetrates the abdominal parietes and empties outwards, thus to discharge the foreign body. Needles found in the subcutaneous connective tissue in various parts of the body, which it is claimed have migrated from the stomach, are to be treated with great circumspection, as herein a number of intentional deceptions on the part of patients are on record (Hager,† Pollock,‡ Doran§).

Furthermore, after it shall have become possible to diagnose cancer of the stomach earlier than it can be as yet (Van der Velden‖) opening the stomach according to the experiments of Gussenbauer and von Winiwarter,¶ will be used not only for the establishment of a gastric fistula, but also for excision of the part of the stomach which has suffered cancerous degeneration (perhaps most frequently the pyloric portion).

Finally, it has been proposed to dilate strictures of the cardiac as well as pyloric ends, through openings made into the anterior walls of the stomach. At all events, no great difficulties will attach to inserting sounds into the cardiac and pyloric ends through the abdomino-gastric wound.

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* Billroth, VI. Congress d. deutsch. Gesellsch. f. Chir. 1877. I. p. 105.

† Hagen, die Fremden Körper in Meüschen. Wien, 1844.

‡ Pollock, Holmes' System of Surgery. 2nd. ed. Art. Injuries of the Abdomen.

§ Doran, Foreign bodies imbedded in the tissues. St. Bartholomew's Hosp. Rep's. 1876, pp. 113 to 124.

‖ Van der Velden, Ueber Vorkommer und Mangel d. freien Salzsäure in Magensaft, etc. Deutsches Archiv. f. klein Med. Bd. XXIII.

¶ Gussenbauer, and v. Winiwarter, Die pertielle Mageuresection. Arch. f. Klin. Chir. Bd. XIX. Heft. 3. (It was proposed by Merren in 1810. Sprengel [Gesehiclete d. Chirurgie] designated the proposition as "Merrem's Dream").

It is said that on July 9th, 1635, Daniel Schwabe, of Königsberg, removed a table-knife by gastrotomy, before the medical faculty of that place. More than two hundred years later Sédillot* (Strassburg, 1849) made a gastrotomy for nutrient purposes in impermeable stenosis of the œsophagus (gastrostomy). His first operations were made in the linea alba, and two years later he transferred the incision to the left hypochondrium. Fenger† adopted this latter plan long ago, and executed it scientifically. Recently Verneuil‡ and Labbé§ made the operation, and to-day the greater part of operators have joined them, adding the application of antiseptics.

Besides operative opening of the stomach, as we will learn to make it, so-called *spontaneous gastric fistulæ* may occur, which are produced either traumatically, as after a stab into the stomach, or in profound or chronic or cancerous tumors of the gastric walls which cause their union with the abdominal coverings, and ulcerations occur which attack the entire abdominal parietes, including the skin.

The sites at which the abdominal walls have been opened to reach the stomach are the linea alba, undoubtedly the most recommendable place; furthermore, in a line parallel to the linea alba, at the lateral margin of the left rectus abdominis muscle, and finally an incision below the left free margin of the ribs, parallel to them and about 3 to 4 c.m. below them.

After incising the abdominal wall, carefully controlling hæmorrhage which, when the linea alba is selected, will be least, the anterior wall of the stomach is reached directly, when it is filled, as under ordinary circumstances. In such cases as require gastrotomy because of danger of starvation in impermeability of the œsophagus, the stomach is found collapsed and drawn backwards and upwards against the diaphragm, thus making its finding difficult, more so when, as it frequently occurs, the transverse colon is tympanitic and presents itself. If care were not employed there might be danger of opening the colon instead of the stomach. To avoid errors *we should, in seeking for the stomach, be guided*

* Sédillot, Comptes rendus de l'acad. des sciences. Paris, 1849.

† Fengen, (Kopenhagen). Virchow's Archiv. Bd. VI. p. 350.

‡ Verneuil, Gaz. Méd. de Paris, 1876; No. 44.

§ Labbé, Note rélative à un fait de gastromie prætiquée pour extraire un corps étranger (fourchette) de l'estomac. Comptes rendus de l'acad. de méd. LXXXII. No. 17, and Gaz. des Hôpit. 1877, No. 49.

*by the gastro-epiploic vessels*, above which the greater curvature of the stomach is inevitably found (Trendellenburg*) If the operation be made for cancerous or still permeable strictures of the œsophagus, the measures recommended by Schreiber and first employed by Schönborn,† may be required. They consist of inserting an œsophageal sound into the stomach; the sound has a rubber balloon attached to its end. As soon as the balloon reaches the stomach it is inflated, whereby the anterior gastric wall is pressed against the abdominal wound.

Various opinions prevail as to the order in which the further steps of the operation should be made. As in opening intra-abdominal cystic tumors (echinococci), we must be guided by the thought that it is desirable first to accomplish an adhesion between the anterior and posterior gastric walls, and to open the stomach subsequently. Thus a needle is inserted into the anterior gastric walls and allowed to lie external to the abdominal coverings, and further steps are deferred to a second seance, at which sutures are inserted between the walls of the abdomen and stomach, and the stomach opened between the sutures. Others, again, filled the wound in the abdominal wall with a ball of Lister's gauze to produce adhesion and incise the stomach subsequently. This means is less safe than the former. But little importance can be attached to the production of protective adhesions in this manner. If it be remembered that gastrotomy gained ground after the value of strict observance of antiseptic rules became appreciated, and if it be considered that neoplasmic connective tissue formation is slower and less in degree than under the influence of stronger irritations to the tissues, we must say that the formation of sufficiently strong adhesions without sutures can be counted upon only when as great a length of time as possible is allowed to intervene between splitting the abdomen and opening the stomach. This should be followed in cancerous strictures, and where the strength of the patient justifies the expectation of a sufficient reaction on the part of the tissues.

At all events, immediate sewing of the stomach to the abdominal wall will produce adhesions and yield an im-

* Frendelburg, Archiv. f. Klin. Chir. 1877, Bd. XXII. Heft. 1.

† Schönborn, Archiv. f. Klin. Chir. 1878, Bd. XXII. Heft. 2, and Verhandl. d. VI. Congr. d. deutsch. Gesellschaft f. Chir. vom Jahr, 1877.

mediate sequestration of the abdominal cavity outwards. In complete impermeability of the œsophaghus, when the patient is near starvation and where nutrition is not sufficient by clysters or cannot be executed, we must immediately proceed to the introduction of food into the stomach. It appears according to the successful cases that as yet have been recorded that the above method of the production of a gastric fistula in one sitting merits preference to all others (Kaiser's*).

After the stomach is found, a fold of its anterior wall is drawn out of the abdominal wound with two forceps. *But care must be taken not to grasp the tissues too deeply towards the greater curvature.* The forceps are substituted by two stout silk threads. At the circumference of the base of the fold of the stomach, thus drawn forth, sutures, preferably of medium catgut or carbolized silk threads, are placed. These are inserted encompassing the serous membrane and muscles of the stomach without perforating the mucous membrane, but taking in the serous membrane of the abdomen at a greater circumference and more or less of the abdominal muscles, according to the thickness of the abdominal wall. Greater care must be exercised in inserting the sutures at both the angles of the abdominal wound.

Within the circle of sutures thus formed lies the fold of stomach which has been drawn out and this must now be incised at the apex of its convexity. It would be well now to unite the margins of the gastric mucous membrane with the lips of the wound in the skin. The union of the skin with gastric mucous membrane, for which thin silk thread is used, prevents the formation of dissecting abscesses between the abdominal muscles, which frequently have been observed after gastrotomy.

The longitudinal diameter of the gastric fistula will have its direction changed according to whether the abdomen is opened in the linea alba or beneath the left margin of the ribs.

If the wound be made at the latter place, the ends are more easily reached and nearly all hæmorrhage is avoided, when, after the incision is made the following steps are taken: The incision begins at the outer margin of the left rectus abdominis, and is continued some 3 to 4 cm. below

* Kaiser, Beits. z. d. operation am Magen. In V. Czerny's Beitr. z. op. Chir. Stuttgart, 1878.

the margin of the ribs and runs slightly concave to them; the abdominal muscles must not be incised in the same direction without consideration of the course of their fibres, *but each muscle that lies within the region is drawn apart with blunt hooks according to the direction of its fibres.* Notwithstanding the various directions of the fibres, a good gaping wound results.

A short thick drainage-tube is to be fastened immediately into the cavity of the stomach; through it the stomach can be frequently washed out and food may be introduced by it (Verneuil, *l. c.*) It is recommendable to use a very wide tube so that large solid bits of meat may be introduced into the stomach which will require less digestive power of the stomach in reference to the amount of gastric secretion used, than nutriment in greater volume, as fluids, or in pieces of greater superficial surface, as, for instance, scraped meat.

The further course of treatment may allow the substitution of the drainage-tube by variously formed obturators, consisting of a short cylinder with two plates screwed to it, one for the gastric wall, the other for the abdominal wall, such as are used for physiological investigations, or tubes may be used resembling tracheal tubes, and having a broad shield for the abdomen. The advantage of such obturators is evident only when the gastric fistula has been made near the greater curvature, and as a consequence allows food, especially in a fluid form, to soon flow out again. Inasmuch as digestion does not take place or is very incomplete, despite the fistula proper, plugging by a good obturator will relieve the trouble at least in good part. Still, obturators frequently produce undesirable enlargement of the fistula and must be entirely omitted.

Patients in whom nutrition has been established by introduction of food directly into the stomach, recover and rapidly increase in weight, if no cancerous stenosis of the stomach obtains. They retain the sensations of hunger and thirst, and endeavor to satisfy the latter by taking fluids, by the mouth, which after being swallowed reach only as far as the stenosis and then are regurgitated. The sensation of taste, as is incidental to taking food by the mouth, is lost. For the purpose of delivering food to the stomach in a most natural condition Trendelenburg (*l. c.*) attached a rubber tube to his patient's fistula-tube, which rubber tube was long enough to reach the patient's mouth. He could

chew his food, mix it with saliva and liquids, and propel it into his stomach through the rubber tube, making it as it were, an artificial œsophagus.

In inoperable carcinomata of the stomach or non-dilatable strictures of the pylorus it has been suggested to open the duodenum directly through the abdominal walls and to use it for the introduction of food, thus excluding and relieving the stomach (Schede.*) As yet but isolated cases which have been operated on in this manner are recorded, yet the probabilities of success of such a procedure are not to be denied for the future. Kaiser (*l. c.*) has shown that the organism can continue to exist after entire or almost entire excision of the stomach.

How shall we succeed in closing gastric fistula of traumatic or ulcerative origin? If the margins of the fistula are freshened and a flap transplanted from the vicinity, it may heal quite well, but as the circulation in the flap is much less developed than in the rest of the skin, it may succumb to the influence of the gastric juice and gradually be digested. The healthy abdominal integument has been observed to show fissures like sites of corrosion where the gastric juice could flow out upon it. This is to be attributed to the above cause (Rose†).

Permanent closure of large gastro-abdominal fistulæ is accomplished only by dissecting the stomach from the wound in the abdominal coverings, and closing the gastric wound. Then the interval in the abdominal wall is closed by a suture or covered by a transplanted flap of skin (Billroth‡).

The treatment of abnormalities which occur at the lower orifices of the intestinal canal and prevent or render difficult the evacuation of fæces must be discussed in this connection. First, we will consider abnormal termination, closure, and absence of the anal opening (anus anomatus, atresia ani, defectus ani).

Abnormal anus opens either anywhere in the skin in the

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* Schede, Verhandl. d. VI. Congr. d. deutsch Gesullsch. f. Chir. 1877, I. p. 107.

† Rose. Ueber einen eigenthüml. zufall n. Gastrotomie. Corresp. Blatt. f. Schweizer Aerzte, 1879.

‡ Billroth, Gastrosaphie. Wien. Med. Wocenschr, 1877, No. 38. Compare Wölfler, Die Mangen banchwandfistel, etc. Archiv. f. klin. Chir. Bd. XX. Heft 3.

neighborhood of the pelvis (anus anom. ext.) as in the sacral or hypogastric region (Littré), or in the umbilical region (Merié), or in the pudenda or even at the penis (Wilkes). Or we will have to deal with an opening of the anus into the bladder, into the vagina or the urethra (anus anom. int.). In all of these cases an opening of the anus into the vagina is the most favorable, because there the least impediment is offered to the evacuation of firm fæcal balls. The most difficult evacuation of fæces is through the male urethra. The vaginal anus is the easiest to treat operatively, *e.g.*, it can be removed with greater facility from the vagina and attached to the normal anal opening.

*Closure of the anal opening* depends either upon a termination of the rectum in a cul-de-sac in the upper perineal region, or upon a funnel-like contraction of the anal opening at its normal place, but above the funnel there is no sigmoid flexure to the colon, or finally an entire arrest of development of the rectal division, or of the colon as far even as the right iliac fossa.

Direct operative procedures are admissible only in cases of atresia ani where the rectum still exists for some distance above the perineum, and where at least a part of the sigmoid flexure is developed. The operation must be performed within a few days after birth if the child is not to be allowed to die.

The perineal raphé is incised, the cut beginning immediately before the coccyx; the connective tissue-layers containing more or less fat are pushed apart, the index-finger is bored in until it strikes the proctodæum, which may then be opened. The higher the intestine lies above the perineum the more difficult will it be to find it, and the more it must be drawn down *to unite the wound in the integument with the lower free margin of the rectal mucous membrane.* All effort must be made to do the latter, partly to avoid the fæcal infiltration of the periprocteal connective tissue, and also to prevent contraction of the newly-made anal opening. Such strictures of the newly made anal opening, like those of the urethra require prolonged treatment with dilating instruments (finger-plugs of tin).

It has been proposed, in entire absence of the sigmoid flexure, when it was desired to succeed in obtaining an anal opening in the perineum, to lay free the descending

* Wilkes, Med. Times and Gaz. 1875, July 24, p. 95

colon in the left abdominal cavity, to open it and to insert a thick bougie. The latter then pushes the cul-de-sac of the gut so deeply against the wound made into the perineum that it will allow cutting down upon the point of the bougie (Martin). Dlauhy's proposition appears less feasible. He proposed to open the abdomen in the linea alba or in the left inguinal region and to seek the cul-de-sac with the finger through these wounds (Kotzmann*).

Most of these cases will probably preclude sewing the anal opening.

But if the large intestine cannot be reached in any manner from the perineum we will have to content ourselves *with the production of a preternatural anus.* The operation will be made on the left side where the descending colon exists, and on the right side when it is absent.

COLOTOMY, opening the large intestine through the abdomen, will have to be performed in total absence of the lower end of the large intestine, in impermeable strictures, or in deformities of the rectum as well as inoperable rectal cancer with considerable contraction. The same principles which we detailed in the discussion of cancerous strictures of the œsophagus and pylorus hold good in this operation, (Curling, Bryant; compare Lecture VIII.)

Two methods have thus far been generally recognized; they are LUMBOCOLOTOMY and LAPAROCOLOTOMY. Duret repeatedly made both of these towards the end of the last century. Littré proposed laparocolotomy as early as 1710, and Pillore performed it in 1776 for rectal cancer. The English claim lumbocolotomy for Callisen (1813). Amussat again recommended it between 1840 and 1850.

LUMBOCOLOTOMY is intended for opening the descending colon at its posterior surface where it is said not to be covered with peritoneum. Midway between the left arch of the ribs and the middle third of the left crest of the ileum an incision is made into the skin begining parallel to both those points, along the lateral margin of the sacrolumbar muscle. Then the deeper parts are cut until the gut is reached, which is best opened parallel to its long axis. It would appear more convenient to incise as before, and to continue along the lateral side of the quadratus lumborum from the margin of the ribs to the crest of the ileum. König (Lehrbuch, Bd. II. p. 309) describes an incision

*Kotzmann, Wiener Med. Wochenschr. 1877, Nos. 23 and 24.

diagonally forwards, descending to the anterior superior spine of the ileum. But lumbocolotomy does not appear to be a recommendable operation; firstly, because of the great depth of the wound; secondly, because of the difficulty of finding the colon; thirdly, because the alleged advantage of extraperitoneal access is illusory, inasmuch as the peritoneal covering of the descending colon but seldom is absent from its posterior surface (in children a mesocolon, even, is often found); and fourthly, because the inconveniences of a lumbar anus are much greater than those situated in the inguinal region (von Erckelens*).

As much as antiseptic precautions deprive intraperitoneal operations of their dangers, so much will we give prefererence to *making a supra-inguinal anus* to *laparocolotomy.* Furthermore it is far more easily executed. In rectal cancer extending high up, as in absence of the sigmoid flexure, we will operate on the left side; while in impediments higher up, and in absence of the entire descending colon, we will select the right side. The abdominal coverings over the gut are slit parallel to the longitudinal axis of the colon by an incision begining 2 to 3 c.m. inwards and upwards of the ant. sup. spine of the ileum, and descending towards the mesian line in somewhat of a convex curve to Poupart's ligamet. The gut is fixed and opened according to the same rules as have been detailed for gastrotomy.

Exactly the same rules govern making *fistulæ of the small intestines*, after opening the abdomen for internal strangulation or invagination of the intestine without being able to find the site of the disturbance. It is hardly necessary to mention that the loop to be selected should be the one which is distended by its contents, consequently one which is above the difficulty. In colotomy, as in restoration of fistulæ in the small intestines, the entire operation should be made in one sitting, and only exceptional cases will permit opening the intestine to be deferred 24 or 48 hours after application of the abdominal sutures.

We will close briefly with the treatment of *foreign bodies in the rectum.* Stercoraceous calculi often of considerable

* Van Erckelen's, Ueber Colotomie, speciel., b. Mastdermstenose durch Carcinom. Mang. Diss. Bonn, 1876. The same contains also statistical compilations of Hawkins, Mason, Tüngel, Curling, Allingham, (St. Thomas's Hosp. Rep. 1870, I. p. 285.) and Adelman, (Prayer Vierteljahschr. 1863), and more extensive bibliography.

dimensions, have been found in the rectum, as have been a great variety of articles which were inserted from without. Small rounded bodies are removed with the fæces or by copious injections of water. Large angular bodies first require injections of weak carbolized oil or similar vaseline (2 to 3 per cent), then they may be extracted with the fingers or grasping instruments (forceps), or they may be levered out with lithotomy-scoops. When very large, or fragile articles, (tumblers, pomade-pots) occupy the rectum, no effort must be made to fracture them, but the patient must be narcotized, and after forcibly dilating the rectum, the foreign body must be levered out by means of the index-finger bent into hook-like form. The latter course must also be pursued in the removal of pointed or sharp articles, especially when they have penetrated the rectal mucous membrane. In such cases specula must be used, through which to grasp sharp bodies without injury to the rectal mucous membrane, and after separating them to remove them. (Compare Marchetti's Case, in Lecture III.). Similar principles govern *the removal of foreign bodies from the vagina.* But in these cases exploration of the rectum and bladder are of great importance in each case, especially when the foreign body is a sharp one, as it may have perforated the anterior or posterior vaginal septum. Barbed articles should always be extracted through a speculum. The bodies most frequently to be removed from the vagina are perhaps neglected pessaries, which have been partly encrusted, and partly held in abcess-cavities formed in the peri-vaginal tissues. These bodies may be broken up before extraction, thus facilitating it. Needles, which project into the rectum or bladder, may be cut in two and one half removed from the vagina and the other from the rectum or bladder as the case may be.

## LECTURE X.

*Dangerous impediments to respiration and circulation resultant upon accumulation or retention of fluids within the cavities of the body, within certain hollow organs and within pathological cystic spaces.*

ACCUMULATIONS OF FLUIDS WITHIN THE THORAX.—*Historical considerations.—Indications for the evacuation of pleuritic exudations in general.—Re-absorption by the pleura.—Pneumothorax, chlylothorax, hæmatothorax.—Treatment of punctures into the pleura.—Opening of the thorax and special indications therefor.*—PUNCTIO THORACIS: *Thoracotomy.—Sites for opening the thorax.—Puncture of the thorax.—Hæmorrhage from the intercostal vessels.—Trocars.—Apparatus for puncture with exclusion of air.—After-treatment of puncture.*—OPENING THE PLEURA BY INCISION.—*Partial sub-perisosteal excision of ribs. —After treatment subsequent to the production of thoracic fistula. —Accumulations of fluids and air in the pericardium and their treatment.—Wounds in the heart.—Electropuncture and acupuncture of the heart.*

GENTLEMEN: My object in adding a brief historical review to this chapter is to offer you therein that most instructive example of the historical development of medicine in general, which it especially contains.

You can convince yourselves that the views which are brought forward herein, and that the therapeutic principles which still are accepted to-day, were recognized since remote antiquity when they existed, only in another form, and that the progress which we claim to have made in our present treatment of the matter really refers only to more complete diagnosis and greater security in the calculation of curative results.

Hippocrates recognized and diagnosticated accumulations of fluids in the thoracic cavity (Succussio Hippokratis). Accumulations of pus were treated by opening the thoracic cavity with a knife or red-hot iron. Preference was given to the knife. Arabian surgery applied the red-hot iron in the treatment of pleural effusions to produce an eschar of

the thoracic wall and to open the pleural cavity through the eschar. Fabricius ab Aquapendente and Paré recommended opening the pleural cavity with a knife. In difficult evacuation of pus, Paré trephined a rib and used the tense opening thus obtained as a means of outflow for the pus, while Fabricius advocated opening the thorax between the fifth and sixth ribs. About 1760 the younger Monro added to the indications for opening the chest in pyothorax and pyopneumo thorax, those of the operative procedures in accumulations of pure air within the pleural cavity to which Itard * (1803) gave the name of pneumothorax.

Soon it was suggested to remove the pleural contents with suction-apparatus after it had been learned to open the thorax with a trocar instead of a knife (Heister, Lurde, 1765). In natural sequence the idea of evacuating pleuritic exudations, under exclusion of the air, was added to the former suggestions. (Krause†, Schuh‡, Wintrich§, Roser‖, Kussmaul¶, Bartels**.) Present times brought forth Dieulafoy's †† apparatus which popularized aspiration of pleuritic exudations to such a degree that the calls for opening the pleura by incision and puncture began to fade in professional favor.

Previous to establishing the special indications, we will elucidate which pleural effusions should be evacuated and when this should be done (compare also Krause, *l. c.*).

1. The operation must be made when the effusion into the pleura imperils vital organs, possibly because of its large quantity, or, what *merits equal consideration, by its rapid accumulation.*

A pleuritic effusion which compresses a lung entirely or crowds the heart out of position and causes even the medi-

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* Itard, Sur le pneumothoror ou les congestions, qui se forment dans la poitrine. Thèse de Paris, 1803.

† Krause, Das Empyem und seine Heilung Danzig, 1843.

‡ Schu—Skoda, Ueber die Entlecrung pleuritischer Exsudate Oesten Jahrbücher 1841, 1842, 1843.

§ Wintrich, Kraukheiten der Respira tionsorgane. Erlangen, 1854.

‖ Roser, Tur Operation des Empyerus. Archiv. f. Keilkunde, 1865.

¶ Kussmaul, Sechszehn Beobachtungen von Thoracoceutese beipleuritis, etc. Archiv. f. klin. Med. Bd. IV.

** Bartels, Ueber die operative Behandlung der entriundlichen Exsudate im Pleurasack. Archiv. f. klin. Med. Bd. IV. p. 263.

†† Dieulafoy, Du diagnostic et du traitement des épauchements aigus et chroniques de la plèvre par aspiration. Bull. génér. de ther. 30 Juin, 1872.

astinal space to bulge towards the other pleural cavity, reduces the respiratory surface in a more dangerous degree when the condition of the other lung is not normal or where rapid accumulations cause rapid and more marked reduction of the respiratory surface. But this is not the only important question which merits consideration in this connection. We know experimentally that the main bronchus of a lung can be entirely closed with a ligature or plugged with a cork without causing the individual's death (Traube, Lichtheim*). It is also known that phthisical patients may live, though the parenchyma of the lung be disintegrated to a high degree. Impediments to the pulmonary circulation are secondarily associated with a diminution of the respiratory surface in compression of the lung by pleuritic exudation (Traube †). But Lichtheim's ‡ investigations show us that closure of the arterial circulation in the lungs, even three quarters in quantity, produces no sinking of the arterial pressure. The flow of blood to the left heart suffers no change because of a compensatory elevation of pressure in the divisions of the pulmonary circulation, which have remained open, is co-incident with resulting increased velocity of flow and extension of the walls of the pulmonary artery. *Dangerous sinking of the aortic pressure in rapid increase of pleural exudation is dependent upon direct compression and displacement of the heart with tension of some and doubling of other large vascular branches.* Bartels (*l. c.*) has demonstrated, post mortem, doubling of the inferior vena cava as a result of displacement of the heart, in exudations on the left side. The deficient filling of the aortic system furthermore produces deficient nutrition of the heart-muscle and thus it is explained how sudden increase of a pleural exudation can produce rapid death, by œdema of the lung in consequence of paralysis of the left ventricle (Welsch§), or by sudden paralysis of the heart and syncope.

Therefore we must operate when great increase of volume

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* Lichtheim, Versuche über Lungenatelektase. Archiv. f. experimentelle Pathologie. Bd. X.

† Traube, Gesanuss Beiträge der Pathologie und Physiologie. Bd. II. and ditto Symptome der Kraukheiten des Respirations und Circulations apparatus. Berlin, 1867, p. 94.

‡ Lichtheim, Die Störungen des Lungenkseislaufee und ihr Einfluss auf den Blutdruck. Habilit.—Schrifs. Breslau, 1876.

§ Welsch, Fur Pathologie des Lungenödems. Virchow's Archiv. Bd. 72. Heft. 3.

on the affected side impedes respiratory motions and the intercostal spaces are strongly bulged outwards, accompanied by intense dyspnœa, while the patient's face is livid and manifests anxiety. We will operate not only in cases of direct imminent danger to life, but also in the slower cases where, though the condition of the patient does not appear alarming, and where he is subject to frequent asthmatic attacks, especially at night, which may produce a sudden strong or great increase of the exudation, and where death often results quite suddenly (Trosseau*, Frantzel†).

2. We must operate in circumscribed purulent exudation (Empyema necessitatis) and then according to the views and laws which apply to the abscesses. Besides antiseptic precautions, strictly followed, counter-openings, drainage, etc., are employed to produce as rapid an evacuation of the pus as is possible.

3. We may operate even though the effusions be not directly threatening, or even when they are of a serofibrinous character, in cases in which the strength of the organism is so exhausted that spontaneous reabsorption cannot be expected soon, or even at all.

4. The operation will be required by large accumulations of air in the pleura (pneumothorax). They may be caused (*a*) traumatically, as after stabs or gun-shot wounds; subcutaneously, but complicated with injuries to the lungs, as in tearing the lung-tissue after violent exertion, or severe contusion of the thorax, or in open fractures of the ribs. Furthermore (*b*), by perforation of inflammatory or necrotic foci in the lungs, through the pleura, as in cavities in caseous pneumonia, or in pulmonary abscesses, or still more frequently in pulmonary mortification. In these cases the question may allow a circumscribed progressive process to the lung surface, or in multiple embolic foci, or mortification in pyæmic processes, or in caries auris int. in ulcerative endocarditis or pylephlebitis. Pneumothorax may also be produced (*c*), by the bursting of emphysematous pulmonary alveoli, by perforation of sharp-pointed foreign bodies or ulcers (especially cancerous) from the œsophagus into the posterior mediastinum, in perforation of the pus from degenerated bronchial glands through the

* Trousseau, Bull. de l'academie de méd. 15 Aoril, 1846.

† Frautzel, Kraukheiten der Pleura. Fiemssens Handb. d. sp. Path. u. Ther. Bd. II. p. 117.

mediastinum into one, especially the left pleural space, and at the same time into the bronchi, or by perforation of echinococcus cysts (from the lung or the liver) into the pleura and synchronously into the stomach or intestine. Finally (*d*), abscesses in the abdominal cavity which conduct themselves in a similar manner can bring about accumulations of air in the pleural spaces. These, just like large accumulations of fluid in the pleuræ, can cause threatening impediments to circulation and respiration. Smaller accumulations of air are re-absorbed spontaneously provided that some cause of irritation has not entered with it. In such cases inflammatory, sero-fibrinous, purulent or ichorous exudation supervenes. When there is an accumulation of air in the pleura, under great pressure, re-absorption thereof is rendered as difficult as are fluid pleural exudations under high pressure.

This deficient re-absorption has been attributed to mechanical closure of the roots of the lymphatic vessels by direct pressure of the pleuritic exudation, for which an explanation has been sought in the experiments of Dybkowsky.* (Frantzel, *l. c.*) Yet even Lichtheim †, early showed how paradoxical this assumption is, by correctly observing that pressure is employed in the removal of fluids from the cavities, as, for instance, in the larger joints. Lichtheim questions curiously whether the pressure upon the re-absorbing surface exerts its influence from within or without. It appears, according to the experiments of Dybkowsky (*l. c.*, p. 207) that the material causes for the lack of re-absorption of considerable exudations into the pleura, consist in an absence of respiratory movements of the affected half of the thorax, and secondly, perhaps, because of the surface stretching of the pleural membrane. The structure of the basal tegument ("Grundhaut") of the pleural membrane, the close network of the bundles of connective tissue, which intercourse each other so extensively, and through the spaces of which the canals of the lymph vessels penetrate to terminate perpendicularly upon free pleura (*l. c.*, p. 201) explain *the stretching of the membrane, especially when, as under such circumstances, the network is con-*

* Dybkowsky, Ueber Aufsangung und Absonderung der Pleurawand. Aus der physiol. Austalt zu Leipzig. Berichte der kgl. Sächs Gesallschraft die Wissenschr. zu Liepzig. Bd. XVIII. 1866, p. 191 ff.

† Lichtheim, Ueber die operative Behandlung pleuritische Exsudate Volkmanns' Klin Vorträge, No. 43, p. 16.

*tracted, and the lumina of the lymph vessels which perforate it must be closed.* They run in but one direction, perpendicular to the long diameter of the intercostal spaces in enlargement of the thorax. According to this a high pressure, with high tension of the re-absorbing membrane, will always produce an impediment, while high pressure, with reduced tension (compression of the joints) would stimulate re-absorption by the lymph vessels. Experimental proof of these questions is urgently necessary.

Very high tension will be attained in pneumothorax, in sub-acute injuries to the thorax (ribs or lungs) while the same would occur in an open thorax wound only when the parallelism between the pleura and external wound is destroyed. Then pneumothorax is often associated with a tensely drawn *sub-acute emphysema* of the thorax, and finally of the entire body. In sub-acute injuries to the thorax deep incisions through the soft parts, especially of the thorax, and subsequent forcing out the air have often attained life-saving results.* It is not permissible to seek for the pleural wound in sub-acute injuries. When the parallelism between the integumentary and pleural wound is lost in complicated injuries to the thorax, the wound in the skin may be enlarged over the opening in the pleura, to impede the further development of the emphysema by re-establishing the communication between the pleural space and the air. Compression and subsequent suture of the integumentary wound must follow.

5. Accumulation of blood or chyle in the thoracic space (principally left) occur after bursting of the thoracic duct (chylothorax), Quincke †, or as hæmothorax after bursting of an aortic aneurism, following ulceration of the aortic wall, or after hæmorrhages from venous vessels (pulmonary veins, vena cava or varicose veins of the wall of the pleura). Blood may also reach the pleural cavity through a tear in the walls of a pulmonary artery, as it courses through a cavern in the lung, perforating the pleura; or when caries of a rib erodes one intercostal artery or another. Penetrating wounds in the thorax with contusion of the lung are the most frequent causes of accumulations of blood in the thoracic space. The most rational procedure evidently

* Koning, Lehrbuch. Bd. I. p. 612.

† Quincke, Ueber fetthaltige Exsudate Deutsches. Archiv. f. Klin. Med. Bd. XVI. p. 121; contains, also, bibliography on the subject.

consists in opening the pleura and removing the blood with antiseptic precautions, at the same time directly arresting the hæmorrhage which, however, is only rarely possible (pin-compression of the intercostal arteries, ligation of the internal mammary artery). Hæmorrhages into the pleura are said to remain fluid a long time (Pentzoldt*). According to the experiments of Wintrich (*l. c.*, p. 363), small quantities of blood are entirely taken up by the pleura, even though there be air coincidentally in the thorax. This merits especial consideration in the treatment of pleural perforations, because it permits us to assume a conservative attitude, provided that the injury has not occurred under too unfavorable circumstances. We may close the wound by button suture, and place the affected half of the thorax at rest. But if fever results, with decomposition of the blood which has been extravasated into the pleura, its removal and subsequent washing of the pleura must not be deferred. In hæmorrhages from the larger vessels (aorta), therapeutics are powerless. In case the hæmorrhage ceases without death occurring from loss of blood, we will proceed to paracentesis, if the extent of the hæmorrhage and consequent pleural exudation threaten life. In chylothorax, paracentesis will be only of transitory use and will not impede the re-accumulation of the fluid.

The means of opening the thoracic cavity to evacuate fluids from it are: 1. Operation by perforation. 2. By incision. 3. By corrosion of the thoracic wall (empyème en plusieurs temps) which now is obsolete.

The special indications for each of these methods are the following:

Perforation or puncture of the thorax must be executed (*a*) in sero-fibrinous exudations and (*b*) in acute purulent exudations that are not extensive.

In accumulations of fluids of a sero-fibrinous consistency we will have to operate at any time when threatening asphyxia occurs. Secondly, we are entitled to puncture, when after subsidence of the inflammatory stage the mass of the exudate appears so large that spontaneous re-absorption of the fluid can not be expected (see above.) In both cases the evacuation must be made slowly in various postures and with strict antiseptic precautions. Only thus will we suc-

* Pentzoldt, Verhalten von Blutergüssen in seröseen Höhlen. Deutsches Archiv. f. Klin. Med. Bd. XVIII. p. 542.

ceed in preventing inflammatory manifestations, in most instances, as also the danger of pyothorax. The latter process is characterized by intense febrile motion or in rapid cases *by the appearance of œdema of the soft parts on the affected side of the thorax*,* similar to those manifestations which Hippocrates observed in purulent meningitis. If, however, antiseptic precautions have been omitted or unsuccessfully employed, and the pleural exudations approach suppuration, strong anti-phlogistic means will have to be adopted, such as application of ice, nitrate of potash, and saline purgatives. If the exudation has become purulent, the second indication for puncture of the thorax is suggested but only experimentally. Results will be obtained only when it is possible to remove the pus by simple puncture alone or aided by antiseptic washing. The fluid which is used for washing must finally run out quite clear before the procedure may be considered as concluded. When re-accumulation occurs the pleural cavity must be opened by incision and then drained.

The operation by incision, *thoracotomy*, must be made in general (*a*) when encapsulated pleural abscesses tend to external rupture (empyema necessitatis). Furthermore (*b*), as we have seen in Empyemas, in which experimental punctures or aspirations failed. Then (*c*) in all empyemas in which there is either direct danger of suffocation or where there is an intense fever, or after conclusion of the acute stage a slow hectic fever (pyæmia simplex chronica) is developed. As we will detail further on, strict antisepsis and *very free evacuation of the purulent pleural contents are the most urgent requirements for success in thoracotomy.*

Previous to a detailed description of the operation itself, the places at which the thorax may be opened must be briefly mentioned:

Encapsulated intra or peripleuritic† exudations present the bulging intercostal space as the site of operation; that is to say, we will endeavor to open the cavity at a point which will insure the most free evacuation. In extensive *free* effusions into the pleural space *we must always operate in the axillary line*, remembering that the right side may be penetrated less deeply than the left, owing to the elevation of the diaphragm which is there arched upwards by the liver.

* Piorry, De la percussion médiate, etc. Paris, 1828, p. 85.

† Wunderlich, Ueber Peripleuritis, Archiv. f. Heilkunde, 1861; also Billroth v. Langenbeck Archiv. f. Klin. Med. Bd. XII. I. pp. 21–43.

Thus Sabatier, Boyer and Pelletan operated between the eighth and ninth left ribs and between the seventh and eighth right ribs, while Chopart and Desault entered more deeply between the tenth and eleventh ribs on the left side and between the ninth and tenth ribs on the right. Evidently the guiding idea in these operations was to seek the lowest point of the pleural cavity. Yet there exist no satisfactory topographical examinations of these conditions, which, however, have lost much of their importance through the introduction of antiseptic treatment, but are of the greatest possible moment in those cases in which antiseptic washings of the cavity are to be united to drainage. The recommendations of Traube, Kussmaul, and Billroth* cause us to select *the axillary line on both sides of the fifth intercostal space*, or, in case of necessity, to limit ourselves to the space bounded by the fourth and sixth ribs. This corresponds to the certainly rational advice given by Bardeleben† to fix the boundary line between the abdomen and thorax and then to operate 5 c.m. above that line on the left side and 7 c.m. on the right.

The establishment of the boundaries between the abdomen and thorax in the different positions of the body, the physical examination of the lungs and the circulatory apparatus, and above all the course of the febrile curve, are the principal points which you will need for the appreciation of each case, in forming a correct opinion of the quantity, consistency, and growth of pleural exudations. You must never omit methodical attention to *each* one of these elements, so that your operative procedures may not be unsafe or perilous to the patient. Thus, for instance, the simple recognition of the boundaries between the abdomen and thorax gives you no key whatever as to the quantity of the exudation, because though the fluid exerts an equal pressure in all directions, the different thoracic walls are differently elastic and consequently are expanded in different degrees with corresponding displacement of the neighboring organs.

As we pass to a special consideration of the modes of operation we must mention that puncture (paracentesis thoracis) was always made under efforts to exclude the air; thus

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* Billroth in Pitha—Billroth's Handbuch d. Chiv. Bd. III. 2. Abth. 152 et sequitur.

† Bardeleben, Lehrbuch, etc. Bd. III. p. 633.

Henricus Bassius (see Sprengel's Geschichte der Chirurgie) recommended drawing the skin so that after the operation it might act as a valve, permitting the outflow but impeding the entrance of air. Trousseau (*l. c.*), who wished to operate according to Boyer's counsel, between the seventh and eighth right ribs, made his diagonal incision at the lower margin of the eighth rib, and drew the wound to the upper margin of the same rib, where he inserted the trocar. The trocar must always be inserted at the upper margin of the ribs *because intercostal vessels course at their lower margins or at the upper boundary of each intercostal space.*

In injuries to an intercostal artery compresses have been recommended which were intended to press the wounded arterial tube against the rib. A much simpler and really efficacious means is to envelop the rib and vessel with a correspondingly thick antiseptic thread on both sides of the arterial wound by means of which the artery is pressed to the rib. This procedure is also the most reliable means in hemorrhage from injured intercostal veins, which may become very copious by the pumping action of the motions of the ribs (Venous pumping, Ludwig Dybkowsky, *l. c.*).

Puncture is made by the trocar, which consists of a canula provided with a sharp-pointed polygonal stylet. For the purpose of impeding the possibility of the entrance of air into the pleural cavity during respiratory movements, many means and manipulations were devised, which were quite important previous to the antiseptic period (use of the spray).

First a cock was provided for the canula. A simpler procedure was suggested, namely, that of placing the finger upon the opening of the canula at each forced inspiration. Schuh had a small trough made, into one of the corners of which, at its base, the canula was inserted, thus keeping it ever beneath the upper level of the evacuated fluid. The same principle guided Biermer's proposition to insert the opening of the canula into a bottle over the margin of which the pleural fluid was to flow. Thompson's and Frantzel's (*l. c.*) T-shaped trocar was constructed on a similar principle. While the stylet can be inserted and withdrawn hermetically in the long arm of the trocar the fluid, only after the stylet is pushed back, can flow from the forward part of the long arm, through the short arm, into a vessel, standing on the floor, to which it is conducted by a long rubber tube, which is fastened to the short arm. The above-mentioned

vessel is filled by a certain (antiseptic) fluid and the free end of the gum tube is continually maintained beneath the upper level of this fluid. We have yet to mention Reybard's well-known proposition, which is not to cover the canula with the point of the finger but to stop it by means of a fish bladder or a condom which had been previously drawn over it, so that a part of the bladder lies curtain-like over the opening of the canula, acting like a flap when it is attracted by reduction of pressure within the thorax.

As has been said, the danger of entrance of air into the pleural cavities through punctures has lost its terrors since the operation is made with carefully disinfected instruments and under the protection of the carbolic spray. The resultant simplicity of the procedure causes us to give it decided preference over aspiration even with such perfected apparatus as were constructed especially by Dieulafoy (*l. c.*)

After executing the puncture we must disinfect the skin for a considerable extent around the opening, and cover it with an antiseptic compress which contains antiseptic sponges, for the purpose of receiving the secretions, which ofttimes ooze from the wound in considerable quantities. After successfully puncturing sero-fibrinous exudations without re-accumulation of the fluid, particular attention must be directed to re-establish normal extension of the lungs, which is brought about by good feeding and vigorous exercise of the respiratory movements (gymnastics and mounting hills).

We evacuate purulent exudations according to the laws which govern the opening of abscesses, and afterwards treat them in the same manner. Antisepsis is important, as also is complete and permanent evacuation of the pus and of the liquids used for washing, all of which is accomplished by adequate drainage. The latter requirements are rather difficult of execution for two reasons: first, as we have seen, because the most pendant point of the pus cavity can be established only with difficulty. On the other hand, because the thoracic fistula contracts with great facility by approximation of the ribs, which depends upon contraction of the walls of the inter-thoracic pus cavity.

Hippocrates recognized this unfavorable occurrence in the free evacuation of pus. Therefore he recommended the insertion of flax pledgets into the wound of thoracotomy. Reybard preferred Paré's direct trepanation of a rib, to thus obtain a tense, non-contractile, thoracic fistula.

We will consider three procedures, which merit discussion for their efficacy in evacuation of inter-thoracic accumulations of pus: first, the insertion of a sufficiently long and amply wide drainage-tube into the pleura; secondly, the production of appropriate counter-openings for the purpose of washing the cavity; and thirdly, partial subperiosteal resection of pieces of one or more ribs, whereby free evacuation is attained in a most admirable manner, and thus also a rapid contraction of the inter-thoracic abscess-cavity.

The execution of *partial resection of ribs* is very simple. After splitting the soft parts and the periosteum on the rib, the latter is lifted off around the rib with an elevator, then the elevator is pushed between the rib and the pleural wall, for the protection of the latter, and the rib is cut through with a bone forceps or sawed with a straight saw. Then the piece of rib which has been sawn through is lifted vigorously out of its periosteal covering, and as much of its length cut off with the bone forceps as may be desired. Subperiosteal excision permits avoidance of injury to the intercostal vessels. These are then ligated *en masse*, with the emptied periosteum of the excised piece of bone and cut through between the two ligatures with the intercostal muscles. Thus as large a wound as may be desired is secured in the thoracic wall without any hæmorrhage whatever.

During execution of resection of the ribs we may wash out the pleural cavity with antiseptics. Pirogoff recommended a one to two-per-cent aqueous solution of tincture of iodine for this purpose. Diluted carbolic acid (10 to 20 per 1000) has been successfully employed; but in children, or where carbolic poisoning supervenes, it may be substituted by salicylic acid (1 to 500) or solutions of thymol (1 to 1000) or solutions of hypermanganate of potash (1 to 500) or even by one-half-per-cent solutions of common salt (Frantzel, *l. c.*, p. 149). Great importance must be attached not only to expulsion of the pleural contents, but also to most rapid and complete evacuation of the liquid used for washing immediately thereafter; this applies especially to carbolic solutions.

*The after-treatment subsequent to the establishment of a thoracic fistula* must be directed especially to good nutrition. The evacuation of the masses of pus which have accumulated under high pressure in the pleural cavity, as well as care

directed to the prevention of a re-accumulation or retention of pus, will contribute most rapidly to an elevation of the patient's strength, as then the absorption of septic pyrogenous matters will be reduced to a minimum. The fever will fall, and with its fall there will be a relief of disturbed nutrition and assimilation which were maintained coincident with increased destruction of albumen. To completely cure the inter-thoracic cavity, rest and residence in a mild climate will be required, besides the appliances for the evacuation of pus, which have been discussed. The more favorable the auspices under which all of these conditions are united, the sooner the thoracic fistula can be cured, which, it is true, often taxes the patience of the sufferer, as well as that of the physician. It occurs, in case purulent pleuritis was not developed in a tuberculous constitution, or in case secondary tubercles were not developed. In some cases we will be justified in stimulating the cicatrization of the cavity by scarification, when the contraction of the inter-thoracic space arrives at a standstill.

When the thoracic fistula is cured, and the contraction of the granulations draw the lung, which had been collapsed, again to the thoracic wall, and the lung-tissue has again become elastic (Billroth, *l. c.*, p. 156), respiratory exercises may be employed to re-extend the lung.

*Accumulations of fluids and air in the pericardium* will require operative procedures much more rarely, although when they exercise great tension they may materially disturb the action of the heart. This applies especially to hæmorrhages into the pericardium, as in spontaneous ruptures of the heart or more frequently in traumatisms of the heart, as in injuries by stabs or gun-shot. Dropsical effusions into the heart-sac occur in affections of the kidneys, but mostly with accumulations of fluid in the pleuræ. If the effusion is rapid, or if re-absorption of a chronic inflammatory exudation is made impossible, by changes in the serous membrane, the increased pressure on the contents of the pericardium may produce disturbances of the circulation and, secondarily, of respiration as well. Anxiety and oppression, dull pressure and a sensation of weight in the cardiac region, are the symptoms which are aggravated by motion, as well as the dorsal decubitis. The heart's action is irregular, arythmic, sometimes small and faint, at other times tumultuous and violent. Extensive filling of the heart-sac is said to produce a bulging from the third

to the fifth rib; occasionally, also, a kind of fluctuation is felt.

Evacuation of pericardial effusions is permissible only when physical diagnosis establishes the effusion and its extent. Dieffenbach (Oper. Chirurgie, Bd. II. p. 397) advocates Karawjew's procedure for large effusions, viz., the insertion of a trocar between the fifth and sixth ribs at a point distant three fingers'-breadth left of the left margin of the sternum through the intercostal space into the pericardium. Roger* bespeaks favor for the application of small capillary trocars, and unites Dieulafoy's aspiration with puncture. Roger prefers the fifth intercostal space as the site of election, and makes the puncture in the parasternal line or beyond it, according to the point of the impulse of the apex. The trocar, then, should not be sunk perpendicularly upon the heart's surface, but, as much as possible parallel to it; thus backwards and towards the mesian line. Skjelderup's† method is much more rational, because it facilitates a view of the parts. He recommended trepanning the sternum between the fifth and sixth ribs, at the union of the cartilage of the fifth rib with the sternum, and thus to expose the heart-sack, which then may be opened by the knife or trocar with complete safety. This procedure is only apparently more injurious than direct puncture of the pericardium. Yet this circumstance merits less consideration, since we do not perform any such operations without antiseptic precautions. Isolated cases of the puncture of pericardiac exudations which saved life, temporarily at least, and in which large qnantities of fluids were evacuated, may, perhaps, admit the explanation that the relief was as much owing to the coincident opening of the left pleura and evacuation of fluid therefrom.

If the accumulation of fluid in the heart is based upon tuberculosis, or if acute pericarditis is only an accompaniment to infectious endo-carditis or myocarditas (as in typhus, acute articular rheumatism, etc.) or dependent on a traumatic inflammation of the heart-muscle, then puncture will accomplish but little.

Purulent exudations in the heart-sac but seldom assume great proportions, and are found as concomitants to and

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*Roger, Bull. de l'acad. de Wéd 1875, Nos. 42 and 43.

†Skjelderup, Acta nova societatas med. Hafriensis. T. I. Hafu. 1818, p. 280.

dependents upon the general condition when post-mortem examinations are made of those dead of sepsis, puerperal fever, or infectious osteomyelitis.

*Accumulations of blood* are found in contusions of the heart, most especially after direct injuries. In the latter cases pneumopericardium may also result. But accumulations of air in the heart-sac have been found after adhesions of it with the diaphragm and the perforation of a gastric ulcer through the diaphragm into the heart-sac (Rosenstirn's case*).

Not all injuries to the heart are fatal. Perforations of the heart have often healed, and cases are recorded where bullets were found encapsulated in the heart-muscle. Bullets may also lie for a long time within a cavity of the heart without producing any disturbances, as can be proven by the introduction of foreign bodies (glass balls, little glass tubes, etc.) into the right heart, through the jugular vein, as is done experimentally. In stabs into the heart, fatal hæmorrhage is prevented, when the penetration has been deep, by closing the wound through muscular action, or through the establishment of a valve-like mechanism. Wounds into the heart have healed by cicatrization where the scar could become adherent to the heart-sac. Small accumulations of blood or air in the pericardium are re-absorbed, as we have detailed in considering these occurrences in the pleura. Recent injuries to the heart, especially stabs, may be best closed by suture, while gun-shot wounds to the heart may be closed by antiseptic compresses, besides which, as is self-evident, absolute rest and venesection are required. Digital exploration of the wound is indicated only when the perforating instrument is broken off in the wound, and could not have been extracted by the witnesses to the injury or by the wounded person himself. It must be done only when the foreign body can be easily reached. Projectiles must not be sought for in injuries to the heart. Paré's dictum, "Je le pansais; Dieu l'a gueri" holds good to-day, owing to the uncertainty of their diagnosis. Acupuncture and electro-puncture of the heart, as have been recommended in paralysis of the heart, to stimulate it to action, as all intentional punctures to the heart, are reprehensible.

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* Timmers, Pneumopericardium, Academisch. Proefschrift. Leiden 1879.

Electro-puncture is reprehensible because weak currents cannot stimulate the heart-muscle, while strong currents may definitely paralyze it. Acu-puncture, to develop mechanical heart-beats, is reprehensible because its result is uncertain, and because fatal injuries to the coronary arteries of the heart may result (verbal communication of a post-mortem examination in Breslau by Prof. Weigert). Instead of acu-puncture, mechanical kneadings of the heart through the thoracic walls are recommendable, as we mentioned in auto-transfusion (Böhm*). Frequently the success of the so-called artificial respiration of Marshall Hall are to be attributed to it alone, especially in chloroform asphyxia, in which the increased flow of blood to the heart is furthered by the forced thoracic movements.

* Böhm, Centralbl, f. med. Wissensehapten (1874) No. 21.

## LECTURE XI.

II. FREE AND CYSTIC ACCUMULATIONS OF FLUIDS AND SWELLINGS FROM RETENTIONS IN THE ABDOMINAL CAVITY.—*Indications for puncture in* ASCITES.—*Sites of puncture.—Operative procedures.—Differential diagnosis from ovarian tumors. —Accumalations of air in the abdominal cavity and intestines.* —ECHINOCOCCUS CYSTS.—*In the liver.—Modes of treatment. —Hydronephrosis. —Etiology and treatment.*—CYSTS OF THE OVARIES.—*Punctures and their consequences.*—SOLID ABDOMINAL TUMORS.

CYSTOTOMY.—*Indications.—Posterior catheterism.—Foreign bodies in the urethra.—Their extraction.—Procedures in cystotomy. Injuries to the bladder.*

HÆMATOMETRA.—*Hydrometra.*

III. PERILOUS CONTRACTION OF THE CRANIAL SPACE (*see below*).

WE must distinguish accumulations of fluids within the abdomen which occur either free in the abdominal cavity (Ascites), or which are found within pathological cystic spaces (echinococci, hydronephrotic sacs, ovarian cysts), or finally such as lead to the development of tumors of retention within hollow organs.

Free accumulations of fluids within the abdominal cavity occur :

1. In chronic inflammation of the peritoneum (peritonitis chronica tuberculosa). If during this process extensive adhesions have been formed, the fluid may accumulate and be encysted in one part of the abdominal cavity, which condition requires differentiation from cystic intra-abdominal tumors when an operation is to be performed.

2. In general hydræmia, such as occurs in prolonged suppurations, in amyloid changes in the organs, in the syphilitic cachexia, etc.

3. In abnormal secretion of the urine in the course of chronic nephritis.

4. In consequence of engorgement of the portal circulation in diseases of the liver or of the heart.

5. In tumors of the peritoneum, and tumors which compress the portal radicle; furthermore, as complications of ovarian tumors ascites presents itself in the train of the inflammatory changes which occur in the peritoneum, or as one of the consequences of the development of a cachexia.

In simple inflammatory processes affecting the peritoneum, the fluid contents of the abdominal cavity appear clear as water, sometimes with a slight yellowish or greenish tinge. Occasionally we find flakes of fibrine, which are formed in the fluid or develop after the extracted fluid has stood. It also contains albumen, which is precipitable by boiling, but no paralbumin is found. The fluid does not coagulate *in toto*, nor does it contain fat (see the accumulations of chyle and so-called hydrops adiposus in the abdomen, Quincke,* *l. c.*) Cylindrical epithelium and cholesterin are not found in these cases, which distinguishes them from ovarian cysts (Waldeyer, Spiegelberg ‡).

The *indications* for the evacuation of the fluids which have accumulated in the abdomen are:

*a.* Impediments to respiration, which result from the diaphragm being crowded against the thoracic cavity and thus a high degree of dyspnœa is developed.

*b.* In violent pains which are produced by pressure upon the sacral plexus or the solar plexus, and

*c.* When the accumulation of fluid exercises a compression upon the vena cava, with œdema of the lower extremities.

1. The *places* through which fluids may be evacuated from the abdomen are very numerous. Formerly the abdomen was punctured through the navel, as was recommended by Hippocrates and Celsus, until Dieffenbach proved the impropriety of puncturing this site, firstly, because the wound heals up slowly, and, secondly, because of the secondary inflammations which easily supervene at this site.

2. The second point for puncture lies in the abdomen between the navel and the symphysis. It has been accredited to Paul of Ægina, and is the method which is preferred in England.

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* Quincke, Ueber fetthaltige Transsudate. Deutsch. Arch. f. klin. Medicin. Bd. 16., p. 128. (Chylous dropsy from bursting of chyle vessels and adipose dropsy from admixture of fatty degenerated endothelium to the serum, or of fatty tumor-cells to the ascites-fluid, as in carcinosis peritonei).

‡ Spiegelberg, Volkmann's klin. Vorträge. No. 55.

3. Half way on a line between the navel and the anterior superior spine of the ileum on the left side, in enlargement of the liver, and on the right side in hypertrophy of the spleen (for instance, after intermittents). This method was preferred in France and Germany, and was recommended by Palfyn and Monro.

4. At the intersection of two lines, one of which envelops the abdomen horizontally from the navel to the spinal column and the other drawn perpendicular to it, from the free margin of the ribs to the anterior superior spine of the ileum.

5. In the left hypochondrium close below the last ribs (Scarpa), as in the ascites of pregnancy, or in large tumors in the hypogastric region. Abortion often follows puncture.

6. In the scrotum (Ledran), when there is a hernial sac communicating with the abdominal cavity; then the site of puncture is the deepest point of the cavity which contains the fluid.

7. Through the vagina (Henkel), or through the rectum (Malacarne). The two latter points of puncture were selected because of the guiding idea, that as they were the most pendent, they would best allow the complete outflow of the fluid. Both of these sites, however, appear disadvantageous because they may easily develop ichorous processes, which may extend to the peritoneum.

Previous to evacuating such fluids as may lie free in the abdominal cavity, we must employ exact percussion of the abdomen while sitting and lying, and on the side, to establish the position and the relations of the intestines to the fluid, so as to avoid injury to the intestine.

When the site of puncture is determined upon, the patient is placed in a half-sitting posture and after again establishing the boundaries between gut and fluid by careful percussion, a small incision is made at the site of puncture. This incision should run parallel to the axis of the body and should penetrate the skin, which is frequently quite œdematous. The trocar, being held in the closed hand, is forced through the wound in the skin by a stout push, not in a boring or screwing manner. Thus, with one smart impulse, it is inserted into the abdominal cavity. The abdomen of the patient is covered above and below the site of puncture by long towels, which envelop the body and have their ends crossed upon the patient's back, where

they are drawn more and more tightly together as the fluid escapes, for the purpose of reducing the volume of the abdominal cavity.

It were well in direct puncture, as when a preliminary incision in the skin is made, to avoid parallelism between the wound in the skin and that in the abdominal muscles by displacing the former previous to the puncture.

Strict observance of antiseptic rules is absolutely requisite to insure against the apearance of inflammatory manifestations after the puncture of ascites. The evacuation of the fluid should take place beneath an antiseptic solution. The same idea governs the use of instruments for aspiration, by which the fluid from the abdominal cavity is sucked into a disinfected vacuum (Traube, Péan). Furthermore, the fluid must be evacuated *slowly, with increasing compression* of the abdominal walls, to avoid tearing of the intra-abdominal vessels,which might result from the sudden relief from pressure. If the canula becomes plugged, as it may, by flakes of fibrine, the canal may be freed by correspondingly thick, bent plugs of metal. When it is decided to conclude the operation, the canula is rapidly extracted and a closely fitting bandage is applied. The bandage contains antiseptic sponges for the purpose of compression. The application of the spray in this instance, as in all punctures of the cavities (thorax, abdomen, joints), or pathological cysts, is highly recommendable. After the operation complete rest is requisite. Formerly the injection of solutions of iodine into the abdomen was recommended (Leriche, Oré, Boinet).

When encapsulated fluids in the abdominal cavity are to be treated, the possibility of confounding them with ovarian tumors must be considered. Careful palpation and percussion of the abdomen, and combined examination per rectum and per vaginam, as well as chemical and microscopic examination of the fluid obtained by an exploratory puncture, will facilitate differential diagnosis (compare the special treatises of Spencer Wells, Spiegelberg, Olshausen). Palpatory examination immediately after evacuating the fluid should not be omitted. Still, errors in diagnosis have been made, even by experienced specialists, but they in all probability will occur less frequently in the future, because simple exploratory puncture will be substituted by an exploratory incision of the abdomen under antiseptic precautions.

*Accumulations of air* in the abdominal cavity (tympanites peritonealis) occur principally after the escape of intestinal gases in perforation of the intestines, but more rarely after perforation of a pulmonary abscess into the peritoneum, which, of course, must be preceded by coalition of the lungs with the diaphragm. Puncture may be made in cases where sudden diffuse septic peritonitis has asserted itself, for the purpose of obtaining relief to respiration; as a life-saving means it would be valueless. König (Handb. II., Theil. p. 50) raises the question whether such desperate cases would not preferably require opening the abdominal cavity by incision, perhaps at two places, with subsequent disinfecting irrigation.

Puncture in *intestinal tympanitis* (recommended by Mothe) promises only subjective alleviation to the patient. Very fine trocars must be employed to avoid the escape of intestinal contents into the abdominal cavity. Interference in these cases can have a life-saving object only when it is directed against the primary cause of the accumulation of gas, that is, in hernial strangulation, or in intra-abdominal closure of an intestinal tube, etc.

*Cysts of echinococcus*, especially in the liver, have as yet been treated in a great variety of ways. When they grow rapidly they cause difficulties similar to those produced by free ascites.

The oldest method, and that which is used almost exclusively in Iceland (one of the principal homes of the development of echinococcus) is cauterization, most frequently with the paste of chloride of zinc or caustic potash (Récamier, Finsen*). This method is very painful and tedious, as the eschar allows the parasitic cyst to open only after the lapse of weeks.

The second method is simple puncture of the echinococcus cyst, with or without injection of solutions of iodine. Contraction of the cyst and death of the parasite has been observed frequently after simple puncture. A contra-indication to simple puncture consists in that it occasionally allows the fluid to escape from the opened echinococcus sac into the abdominal cavity. In the most unfavorable cases, when the echinococcus fluid escapes clear and undecomposed, there results a distribution of entozoic germs

* Finsen, Bidrag til Kundsgab om de i Island endemiske Echinokoker. Ugeskrift for Laeger. Raidke, 3. Bd. III. No. 5, 8.

into the abdominal cavity as in spontaneous bursting of echinococcus sacs. If the fluid contains pus diffuse septic peritonitis will result.

Therefore if it is decided to evacuate the contents of a cyst by puncture, Simon's* method of DOUBLE PUNCTURE deserves preference. It entails, previous to opening the cyst, the production of adhesions between the cyst-wall (surface of liver) and the abdominal parietes. Then two long, thin exploratory trocars are thrust into the cyst. Their stylets are removed, and after the evacuation of a certain quantity of the fluid the openings in the canula are plugged with carbolized wax. The canulæ are allowed to remain as long as eight days, continuously covered with antiseptic dressing. The object desired to be obtained by this is the formation of adhesions around the sites of puncture. When it is decided that the adhesions are sufficiently firm and extended, the abdominal coverings are carefully incised between the canulæ down to the walls of the cysts and then the latter is opened by a broad incision.

The formation of adhesions under rigorous antiseptic precautions was achieved by Volkmann,† following the example of Bégin, for opening abscesses of the liver, and that of Costallat for colotomy or for enterotomy. He slit the abdominal coverings directly to the surface of the liver or the echinococcus sac, and after filling the slit in the abdominal wall with pressed Lister's gauze (Krüllgaze) he covered all with an antiseptic compress. The antiseptic dressing, which had been pressed in, acts similarly as does the introduction of the trocar-canulæ in Simon's method. When the adhesions are sufficiently resistent, the incision into the cyst is made and then the cavity is washed out with antiseptic solutions previous to the introduction of a sufficiently wide drainage-tube, which will eventually permit the passage of even larger secondary vesicles.

König (*l. c.*, p. 59) considers it safer not to open the peritoneum immediately, but at first to split the abdominal coverings only and to defer the peritoneal incision to the sec-

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* Simon, Deutsche Klinik. 1866, p. 388, 404, 416. See also, Robert Busch, Einige Fälle von Echinococcus hepatis Inaug.-Diss. Rostock 1864. Furthermore: Uterhart, Berliner Klinische Wochenschrift, 1868, No. 14, 16, and 17.

† Ranke, Verh. des VI. Congr. d. deutschen Ges. f. Chir. Grössere Vorträge, p. 54.

ond séance, when he cuts it with the superficial layers of the liver, or the cyst itself.

The treatment of *Hydronephrosis* has been admitted to the domain of operative surgery only since the introduction of the antiseptic treatment of wounds. Hydronephroses owe their development to urinary engorgement such as occur in the formation of calculi in the pelvis of the kidney. A further cause of this engorgement has been attributed to valves at the ostium pelvicum of the ureters, which valves are either congenital (Wülfler,* Englisch) or formed secondarily (Baum, Simon).

Previous to proceeding to operative treatment it is important that we elicit the functional capacity of the other kidney by determination of the solid constituents of the urine. When the contents of the hydronephrotic sac are clear and undecomposed, and when the tumor is not very great, it may be punctured and iodine solutions injected into it. In pyonephroses double puncture has been suggested, as in echinococci of the liver.

In isolated cases the abdomen was opened immediately after previous puncture and efforts were made to extirpate the cystic sac, or, when this proved inexecutable, at least to obliterate it by splitting the sac and sewing the cyst wall into the abdominal wound and subsequent drainage was established. ECHINOCOCCI OF THE KIDNEYS (as also of the spleen, omentum of the Cavum Douglasii, etc.) must be treated according to the principles that have been laid down in the treatment of Echinococci of the liver.

In reference to *ovarian cysts*, the treatment of which can not be detailed here, we will but cite that their puncture must be executed only in direct danger to life, that is, in the occurrence of high degrees of dyspnœa, compression of the vena cava, with œdema of the lower extremities, anuria, symptoms of incarceration, ileus, danger of rupture of the cyst, with coincident pregnancy. After removal of the danger to life, ovariotomy should be performed as soon as possible. Puncture of unilocular cysts (dropsy of the ovarian follicle and parovarian cysts) has succeeded in producing a radical cure in isolated cases only (Schatz†). In multilocular ovarian tumors, puncture of the swelling is to

* Wölfler, Neue Beiträge zur chirurg. Pathol. d. Nieren, von Langenbeck's Archiv. 1877. Bd. XXI. Heft 4.

† Schatz, Archiv f. Gynäkologie. Bd. IX, p. 128.

be executed only, omitting the question of direct danger to life, for diagnostic purposes, previous to operation, or for reduction of the tumor during the operation. Pregnant women, in most instances, bear palliative punctures of ovarian cysts without functional disturbances.

As in the treatment of ovarian tumors, so also in *rapidly growing solid tumors in the abdominal cavity* (tumors of the uterus, of the omentum, of the spleen, etc.) also in ruptures of the uterus with extrusion of the child into the abdominal cavity, opening the abdomen (laparotomy) is to be made whether it be only for diagnostic purposes (exploratory incision) or for the total removal of foreign bodies (tumors, fœtus with placenta, etc.). If the rapid increase of volume of the tumors produces functional disturbances as in ovarian tumors, their removal must be added to the procedures which are considered among those for direct life-saving.

Cystotomy (punctio vesicæ) serves for evacuating the urine from the bladder in cases in which the natural way is interrupted in any manner. Formerly cystotomy was made more frequently. It was employed in every urethral contraction when the introduction of a catheter was not immediately successful. Now owing to the perfection of catheterism, as also owing to the progress in the treatment of strictures of the urethra, only the following indications for cystotomy remain:

1. Sudden retention of urine, with danger of rupture of the bladder in inflammatory swelling of the prostate, as for instance, when false passages have been made in it, or in its surroundings, by the catheter. In acute retention after contusions of the urethra we will proceed to relief of the difficulty by cystotomy, when we find it impossible to introduce a permanent cathether, after splitting the injured urethra through the perineum. In such cases in which the central part of the urethra is not discoverable, R. Volkmann* employed posterior catheterism, as was done by Hunter, Verguin and Brainard. For this purpose the puncture into the bladder is made in the linea alba somewhat above the symphysis. A thin elastic catheter, armed with a curved mandrin, is pushed through the canula into the vesical orifice of the urethra through the membranous part to the wound, which was made by splitting the crushed

* Ranke, Beitrag zum Catheterismus posterior. Deutsche medicin. Wochenschrift. 1876. Nos. 6 and 29.

or strictured part. Thereupon a thread is fastened to the point of the catheter, which projects into the wound, while the beak of a Nélaton's catheter is attached to the other end of the thread and then the latter is drawn into the bladder through the wound. Then a second catheter, inserted through the meatus, may be attached to the free end of Nélaton's catheter, which is drawn in through the wound, thence through the urethra until it projects from the meatus. When the outflow of urine through the wound has emptied the bladder the operator may be compelled to substitute the simple puncture by hypogastric cystotomy (sectio alta) so as to enable him to make posterior catheterism. After introducing the catheter through the abdominal wound, and thence through the vesical opening of the urethra, the canula which rests in the bladder may be removed entirely, which appears less dangerous when we remember that it is permissible to allow a canula to remain *in situ* from six to ten days for the purpose of forming a vesico-abdominal fistula. Likewise posterior catheterism is recommended for gun-shot wounds of the urethra in military surgery.

*Foreign bodies* may so block the urethra as to produce complete retention of urine. Such foreign bodies usually *descend from the bladder* into the urethra and become wedged in there (renal calculi, small vesical calculi, fragments of stone after lithotripsy) or they may be introduced *from without* by masturbation (stones, pins, needles, sticks, lead-pencils, straws, corn, pits of fruit), or they are the result of the breaking off of instruments which have been introduced in surgical operations (catheters, bougies, etc.). The removal of foreign bodies is indicated first on account of the primary retention of urine; then because the presence of the foreign bodies may produce inflammation and swelling of the urethral walls and produce secondary retention, and furthermore, because the body that has been wedged in, if left to itself, will be removed only by suppuration, ulceration and perforation of the surrounding tissues. Foreign bodies which rest directly behind the cutaneous urethral slit, as in the fossa navicularis, may be removed by forceps or scoop-like levers in case simple pressure does not suffice to extrude them. In urgent cases the urethra may be split from above downwards at its cutaneous part, and thus somewhat enlarged. Rounded bodies that have slipped in more deeply may be removed by Leroy d'Etoilles' curette articulée, the closed lever-end of which is inserted and

passed beyond the foreign body, then its flap is brought to a right angle to the long axis of the instrument by a screw apparatus in its handle. The foreign body may be drawn forth by the scoop thus formed. Long bodies (sticks, pieces of catheter, etc.) will require fine forceps, like those of Colin, for their removal, or an instrument may be used which is modeled after the grasping bilabial and trilabial instruments which were formerly employed as lithotrites. In these a bent grasping arm passes through a tube and may be pushed out of it (Hale's and Hunter's forceps). When the foreign body is about to be grasped, the left hand must crowd it from the root of the penis towards the instrument. A pin which lay in the urethra with its head towards the bladder and its point forward, was extracted by Dieffenbach, who pressed on the head of the pin through the rectum and forced the point through the perinum outwards, where it was grasped by a forceps and extracted.*

Secondly, cystotomy is indicated in chronic swelling of the prostate, whereby new inflammatory increase of the gland results in an absolute impermeability of the urethra. As a rapid increase of the contents of the bladder produces an engorgement of the plexus venosus pudendus, therefore evacuation of the bladder by cystotomy often produces a rapid and frequently long-continued decrease of the swelling of the gland by reduction of its sanguineous contents.

Similarly, cystotomy acts in tumors of the pelvis, which compress the prostatic part of the urethra. In these the evacuation of the bladder relieves the engorgement and the venous repletion of the tumor is reduced so that the flow of the urine through the urethra is re-established. As to the various procedures in cystotomy we can advocate but one, namely, *hypogastric puncture.* We mention the other methods merely not to leave them unnoticed:

First, perineal puncture, in which, with or without previously slitting the skin, the trocar is plunged into the bladder in the same course as is traversed in lateral lithotomy. This procedure is not recommendable because of the considerable injuries which it entails.

Cystotomy through the rectum is equally reprehensible, on the one hand because permanent insertion of a canula appears impossible, and, secondly, because the operation is rendered extremely difficult when there is considerable

* Dieffenbach, Operat. Chirurgie. Bd. I. p. 44.

swelling of the prostate, and, furthermore, it does not exclude the possibility of injuries to the peritoneum. In women it has been proposed to puncture the bladder through the anterior vaginal wall, but then in all probability a vesico-vaginal fistula will result, requiring another operation for its closure. Finally, we will mention Voillemier's subpubic puncture. In it the penis is drawn vigorously downwards and the trocar is inserted sideways into the suprapenal ligament and sharply turned around the symphysis, to be conducted into the bladder.

The safest and most convenient means is *suprapubic cystotomy*. In it injuries to the peritoneum rarely occur, because whether a swollen prostate or pelvic tumor compress the neck of the bladder, the latter organ will be lifted and crowded against the suprapubic region, consequently the perineum will be lifted out of the way. The relations are shown most clearly in the experiments of Braune and Garson* on dislocations of the bladder and of the perineum in dilatation of the rectum. We can always produce the crowding upward of the bladder and displacement of the peritoneum by inserting a colpeurynter-like apparatus high up into the rectum and distending it with air or water.

The operation is best executed by first making a small incision over the symphysis in the linea alba through the skin, which has been well shaved, and then between the muscles. Thereupon a semilunar-curved trocar (Mery, Frère-Cosme) is thrust through the wound at a distance of about one to two c.m. above the symphysis.

After removal of the stylet the canula is allowed to remain from six to ten days, which results in the rapid formation of a vesical fistula. The removal of the canula from the fistula is permissible only after the urethral stream is re-established. The vesical fistula heals very rapidly after removal of the canula in a similar manner as we have observed in the wounds of tracheotomy. Bell devised a catheter-shaped rounded little tube to be pushed through the canula and to cover its intracystic end to protect the wall of the bladder against such irritation as the margins of the canula might produce. To facilitate the removal of the canula from the bladder a bent staff (Zang's "Docke")

* Garson, Ueber die Dislocation der Harnblase und des Peritoneum bei Ausdehnung des Rectum. Archiv f. Anat. und Physiol. 1878. Anat. Abth

must be inserted through the canula into the bladder. The canula can be removed and again inserted over the guide thus established. The canula may be fixed into the bladder by attaching threads to its shield and fastening them to the abdomen with adhesive plaster or by tying the ligatures to bundles of the pubic hairs just as the fixation of a permanent catheter can be made (Thompson).

The application of antiseptic bandages must be omitted, as is self-evident; but it is recommendable to insert a piece of lint which has been anointed with carbolized vaseline (2 to 3 per cent) several times a day between the plate of the canula and the skin. The mouth of the canula may be stoppered with a plug of carbolized wax so that the evacuation of urine may take place only at certain intervals or the urine may be allowed to flow off through a long rubber tube which conducts to a vessel filled with a carbolic acid solution. It goes without saying that the patient must remain in bed until the canula is removed.

Injuries to the bladder are made by blunt bodies upon which patients spit themselves either through the rectum or perineum, as also in multiple rupture of the pelvic bones, and most frequently by gun-shot. Injuries by lances or arrows are more rare. In but about one quarter of the cases, the injury is intra-peritoneal while extra-peritoneal injuries are far more frequent. Traumatisms of the bladder are often united with injuries to the pelvis and to the rectum, as has been noted. Bartels * found 74 coincident lesions of the rectum and 196 cases of coincident injuries to the pelvic bones in 504 cases. Gun-shot wounds of the bladder are usually perforating, as the ball frequently penetrates the bladder in two places. It is but rare that the ball remains in the anterior wall of the bladder, as in extra-peritoneal injuries, and yet more rarely has it been found to penetrate the anterior wall and remain imbedded in the posterior wall. † There it may remain for many years unnoticed until symptoms of stone present and call attention to the foreign body. The same applies to sticks, arrow-heads, fragments broken from the pelvic bones, etc., which have penetrated into the bladder.

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* Bartels, Die Traumen der Harnblase. Archiv f. klin. Chirurgie. Bd. XXII. Heft 3 and Heft 4.

† Wilms und Bartels, VIII. Congr. d. deutschen Ges. f. Chir. Verhandl., p. 74–76 of kleineren Mittheil.

Intra-peritoneal injuries to the bladder have terminated fatally in most instances. In these, the evacuation of urine into the abdomen does not provide the fatal essential. Undecomposed urine in limited quantities has been reabsorbed by the peritoneal cavity without injury,* but the complicated character of injuries to the bladder usually brings with it a decomposition of the urine and thus gives cause for the appearance of fatal, diffuse, septic peritonitis if the walls of the bladder have been directly injured or if its peritoneal covering be but lightly furrowed. As soon as the crushed serous surface becomes necrosed, the carriers of infection enter the abdominal cavity unimpeded, though later than in the case before mentioned. In the case of intra-peritoneal injuries to the bladder tabulated by Bartels (*l. c.*, 131 cases in 504) all terminated fatally with exception of a single one, in whom a laparotomy was made and the abdominal cavity washed out. This indicates to us that as soon as a shot into the bladder is diagnosed (bloody urine, flow of urine out of the wound) and manifestations of peritonitis present, we must proceed to laparotomy, to disinfection of the abdominal cavity, and, if possible, to sewing up the wound in the bladder with introduction of a permanent catheter through the urethra. Maximow's † experiments, as well as the frequently unfortunate cases, show us that when a suture of the bladder is made and the stitches penetrate the entire thickness of the vesical wall it is advisable to *avoid encompassing the mucous membrane in them.* The stitches must be placed very closely together.

If, when no opening of the abdominal cavity has occurred our attention must be called, in injuries to the bladder, to impeded stagnation and decomposition of the urine in the bladder and in the wounds which communicate with it,

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* Undecomposed bile as well, even in large quantities, does not exert a disturbance within the peritoneal cavity. Compare Verhandl. der deutschen Gesellschaft f. Chirurgie, VIII. Congress, 4. Sitzung, April 19th, 1879, p. 120.—Bostroem ligated the Ductus choledochus of a dog, with antiseptic precautions. After complete healing, the right hypochondriac region was opened and a part of the wall of the gall bladder was excised, whereupon the abdominal cavity was entirely filled by the bile which had been engorged in the gall bladder. The abdomen was then sewed up. The animal survived without reaction. After eight days he was killed and neither bile nor coloring matter of the bile, was found in the bladder.

† Maximow, Versuche über die Anwendung des Catgut zur Blasennaht bei der Epicystotomie. Inaug.-Diss. St. Petersburg, 1876.

Maas* recommends the administration of large doses of salicylic acid (10 to 12 grams per day). Stagnation of urine is not entirely prevented by the introduction of a permanent catheter. Narrow wounds must be split and free perineal incision must be made to offer a means of unimpeded outflow to the urine. In gun-shot wounds of the bladder, which perforate the rectum, and where the urine might accumulate in the rectum, Simon recommends cutting the sphincter ani. Simon's case (1870) thus recovered with, relative rapidity (Maas, *l. c.*).

*Accumulations of fluid within the uterus* occur in congenital atresia of the os or when the latter becomes closed as a consequence of inflammatory processes (as after careless cauterizations) and where stenoses of varying degrees may present at the inner or the outer os uteri. The latter is more frequent. When the question is not alone one of narrowing of the cervix uteri, but also one of a firm extensive obliteration, the menstrual blood will accumulate in the cavity of the uterus, become inspissated, and with each new menstrual period will extend the womb and the tubes more and more to such a degree as to threaten bursting and evacuation of the contents into the abdominal cavity. Hæmatometra, which have been caused in this manner, produce inexpressible intense and periodically increasing pains like those of labor, and further difficulties. Peritoneal inflammations in the surroundings of the womb frequently result. This is particularly important. *The treatment* of hæmatometra consists of puncture of the uterus through the vagina, with a curved trocar, preferably through the obliterated mouth of the womb, if it can be reached. This is particularly to be considered in so-called unilateral hæmatometra, that is, in retention of the menstrual blood in double womb. The closure of a horn of the uterus can result first from atresia hymenalis of its vagina, secondly by atresia of the horn of the uterus itself, and thirdly in entire or partial absence of a vagina, so that it terminates immediately, or a short distance above, the introitus vaginæ.

The puncture must be made slowly, preferably in several operations, so that the sudden evacuation of the retained menstrual blood, with consequent collapse of the cavity of the uterus, may not produce tearings of the body of the

* Maas, in König's Handb. d. Chir. Bd. II. p. 360.

womb, and especially of the tubes, on account of the above-mentioned peritoneal adhesions, which would result in immediate perforations into the abdominal cavity. Fatal peritonitis from perforation by bursting of a tube has frequently been the consequence of too sudden puncture of hæmatometra.

Secondly, the evacuation of the retained menstrual blood must be made with the strictest antiseptic precautions and a free outflow of the uterine contents must be provided by the insertion of permanent canulæ or excision of pieces of the hæmatometra which present in the vagina.

If distortions or marked contractions of the mouth of the womb result after the menopause in older women, then hydrometra result by engorgement of the uterine secretions which may produce dangers and difficulties equal to those of hæmatometra, and will require analogous treatment. The details which refer particularly to these cases, as well as the differential diagnosis of hydrometra from hydronephrosis, pregnancy, and above all from ovarian tumors, must be sought for in special gynæcological works. Compare also the writings of Kussmaul,* Fürst,† Heppner,‡ Rose,§ Schroeder,‖ which discuss these matters.

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* Kussmaul, Von dem Mangel, der Verkümmerung and Verdoppelung der Gebärmutter, etc. Würzburg, 1859.

† Fürst, Ueber Bildungshemmungen des Uterovaginal-Canals. Leipzig, 1868.

‡ Heppner, Ueber einige klinisch wichtige Hemmungsbildungen der weiblichen Genitalien. St. Petersburger Med. Zeitung. N. F., Bd. I, Heft 3.

§ Rose, Ueber die Operation der Hämatometra. Monatsschrift für Geburtskunde, XXIX. 1867.

‖ Schroeder, Kritische Untersuchungen über Diagnose der Hæmatocele retro-uterina. Bonn, 1866.

## LECTURE XI.—(*Continued.*)

III. CONTRACTIONS OF THE INTRACRANIAL SPACE PERILOUS TO LIFE.—*Normal pressure within the cranial cavity.—Increase of intracranial pressure and transferability of the cerebro-spinal liquor.—Its relations to the lymphatic circulation.—Cerebral hyperæmia and its consequences.*

CEREBRAL COMPRESSION: *Its causes.*—INTRACRANIAL HÆMORRHAGES.—*Injuries to the venous sinuses and their treatment.—Hæmorrhages from the middle meningeal artery.—Symptoms.—Ligation of the middle meningeal artery.—Hæmorrhages from the cerebral division of the carotid artery.—Hæmorrhages between the dura mater and pia mater.—Reduction of space by* FRACTURES OF THE SKULL AND FOREIGN BODIES.—*Complicated injuries to the skull, prognosis, results.—Symptoms of cerebral contusion.—Antiseptics in injuries to the head.—Attainable results.—Treatment of infected injuries to the skull.—Action of antiseptic douche, ice, venesection, purgatives, inunctions of ung. ciner.—Operative interference in inflammatory stage of wounds.* CEREBRAL ABCESS.—*Difficulties of diagnosing locality.—Treatment of open and covered cerebral abscesses.—Cerebral motions.—Causes.—Absence of cerebral motions.—Treatment of prolapsus cerebri.*

CONCUSSION OF THE BRAIN, COMMOTIO CEREBRI.—*Symptoms.—Pure and complicated descriptions.—Theories.—Light and severe cases.—Course and termination.—Treatment of concussion of the brain and sequalæ.*

TREPANNING.—*Indications.—Instruments.—Mode of procedure.—Processes which occur in wounds from trepanning.*

The disturbances which are produced by contractions of space within the cavity of the skull interest us particularly, partly because of the diagnostic difficulties which they offer and partly because of their eminently dangerous significance. Therefore we have deferred their detailed consideration until now. The establishment of precise and clear points of view for the treatment of the disturbances is of

the greatest importance here. And perhaps in no other domain have experiments upon animals contributed so much to the elucidation of the symptomatology and for the acquisition of firm rules for the institution of life-saving means.

Finally, there is no better measure for the value of the antiseptic treatment of wounds than that which results from examining the successes which were attained in even the most difficult injuries to the skull and the brain.

Even such an exemplary work as the excellent treatise of Bergmann* could do but partial justice to the new and unexpected therapeutic prospects, as it was published shortly before the antiseptic period.

To thoroughly comprehend the occurrences in contractions of the cavity of the skull, we must impress upon our minds that the space is bounded in childhood by compressible and extremely elastic bony walls, which, however, become quite firm and less elastic with increasing years. Within that space we find partly solid masses, the brain, partly liquids, like the blood, lymph and cerebro-spinal fluid. The solid as well as fluid parts must be considered as incompressible when subjected to the ordinary state of pressure within the skull. When limitation of the cerebral space occurs by the introduction of a foreign body (projectiles, knife-blades, etc.) or by pathological products (hæmorrhages, pus, etc.) the limitation can occur only by crowding out the fluid parts. The solid brain, on the contrary, can suffer reduction only by partial destruction and removal from the cranial cavity, or in slow compression, by atrophy.

Of the fluids within the skull the cerebro-spinal liquor is most easily displaced. Its removal from rather large space is made possible because of the free communication of the sub-arachnoid spaces of the brain with the arachnoid spaces of the spinal marrow. The latter, the spinal dura mater, is capable of considerable extension; first, by the compressibility of the venous plexuses, which lie around the spinal dura mater within the spinal canal; secondly, by the elasticity of the lig. flava, which are stretched between each vertebral arch by those of the membrana obturatoria atlantis anter. et post., as also by those of the sheaths of the structures within the inter-vertebral orifices.

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* Bergmann, Die Lehre von den Kopfverletzungen. Pitha und Billroth's Sammelwerk, III., Bd., 1 Abth. 1873.

Furthermore, it is important to consider that all of the blood-vessels of the brain—arteries, as well as veins—are involved by perivascular lymph-canals (His*) the contents of which are emptied into the epicerebral lacunæ. The latter are in communication with the arachnoid sac between pia and dura mater and also with the sub-arachnoid spaces by means of the lymph-vessels of the pia mater (Golgi, Key, and Retzius†). The significance of these spaces as lymph-spaces was shown by Schwalbe‡; their lymph to a certain extent is poured into the branches which unite to form the internal jugular plexus, and thus they reach the lymph-vessels of the neck (Arnold).

The lymphatic circulation is capable of serving as a regulator only in gradual changes in the volume of the cranial contents. The changes in the quantity of blood in the brain which are brought about by the systole and expiration, and more so, all greater and sudden changes of volume within cranial cavity, call forth questions as to the modifications which result from variations in the tension of the cerebro-spinal liquor.

Such changes in tension within the cranial space are caused primarily by a repletion of blood in the brain, be it that a fluctionary arterial hyperæmia, or that venous engorgement prevails. In both instances the tension of the cerebro-spinal fluid finally rises so high that a compression of individual capillary districts in the cerebral circulation is brought about. The impediments to the movement of blood thus caused, bring about the retardation of the arterial current in the brain. *This retardation causes the nutrition of the brain-centres to suffer in a similar manner as they do when there is a reduction of the mass of blood which flows through the brain, thus as in cerebral anæmia* (Althann §). The above conditions are particularly observable in that repletion of the cerebral circulation which is not dependent upon increase of the heart's action, but upon a paralysis of the vasomotor nerves, with a relaxation of the vascular walls.

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* His, Ueber ein perivasculäres Canalsystem in den Central organen und dessen Beziehungen zum Lymphsystem Zeitschrift f. wiss Zoologie, 1865, Bd. XV., p. 127.

† Key and Retzius, Injectionen in die Limphräume der Schüdelhöhle. Nordisk Medic. Arkiv. Centralbl. f. die Med. Wissensch. 1871, p. 514.

‡ Schwalbe, Der Arachnoidealbraum ein Lymphraum, Centralbl. f. die Med. Wissensch. 1869. No. 39.

§ Althann, Der Kreislauf in der Schädelrüch gratshüle. Derpat, 1871.

This is, as we shall see, of importance in the conditions which follow concussion of the brain.

All injuries which limit the space of the cranium act like hyperæmias of the brain. They increase intracranial pressure by elevating the tension of the cerebro-spinal liquor, and hamper the circulation by compression of the capillaries. The second disturbances of nutrition manifest themselves in modifications of the brain functions, as we shall have to consider more in detail when discussing the complex number of symptoms of compression and concussion of the brain. Compression of the brain is brought about when the space within the skull is limited. In chronic limitations of the space, as we see it in osteo-sclerosis cranii, when the cranial cavity contracts in all its parts, or in exostoses or tumors, which grow from the cranial capsule towards the brain, and exert local contraction, no cerebral pressure occurs. The quantity of cerebro-spinal fluid accommodates itself to these encroachments, or the otherwise incompressible brain is reduced by atrophy. The symptoms of brain-pressure, however, are observed immediately in sudden compression of the skull on all sides, as Schwartz* proved experimentally with very young animals. The same symptoms are seen, furthermore, when a traumatism crowds the bony skull wall *in toto* inwards at any place.

The manifestations of compression of the brain will thus be most frequently observed as the results of forces which directly strike the skull, consequently in injuries to the head. Among the consequences we note extravasations of blood within the cranial cavity, or fractures of the skull, with depression or penetration of foreign bodies, or finally, accumulations of inflammatory exudations, which are the essential elements to a pressure on the brain.

In extravasations of blood, penetration of bone-splinters and foreign bodies, the manifestations of cerebral compression will follow the injury immediately or occur very soon thereafter; consequently we designate them as primary symptoms. In the accumulation of inflammatory products within the cerebral cavity the symptoms of cerebral pressure occur only a length of time after the injury and consequently bear the name of secondary symptoms.

*Extravasation of blood* is the most frequent cause of primary cerebral compression. It may occur from any of the ves-

* Schwarz, Archiv. f. Gynökologie. 1870. Bd. I., p. 364.

sels of the interior of the skull. The manifestations of cerebral pressure, when hæmorrhage occurs, appear somewhat later than in depressed fracture, because the effused mass of blood must acquire certain dimensions before a dangerous increase of the intracranial tension can take place. Therefore small quantities of blood can be poured out without any further symptoms being developed, but they may assert themselves when arterial hyperæmia or inflammatory processes occur with the hæmorrhage.

Hæmorrhages of the skull occur either outwards or inwards, or synchronously in both directions. Hæmorrhages outwards are usually from the sinuses of the dura mater, from the meningeal artery, and (rarely) from the internal carotid. When these vessels are injured without open fracture of the skull the blood is usually poured between the dura mater and the cranial bones.

*Injuries to the walls of the sinuses* occur usually by instruments which have perforated the cranial cavity, or by bits which have been splintered off from the bony cranial walls, be it that the fracture of the skull is complicated with injury to the soft parts of the skull or not, and finally in stretching or extension of the sinus when the capsule of the skull is pressed together. Such ruptures of the walls of the sinus occur in births when the child's head passes through a narrow pelvis. Again, they occur in fractures of the bones, especially those of the base of the skull. True ruptures more frequently affect the transverse sinus than they do the longitudinal one. The latter, however, is more frequently exposed to injury by foreign bodies, which strike the cranial arch. The cavernous sinus is also injured when perforating instruments penetrate the inner orbital wall. Injury to the sinus confluens is of rare occurrence.

When wounds in the sinus communicate with a complicated fracture of the skull and the blood flows only outwards, the hæmorrhage may be arrested in most cases by direct compression of the wound. However, when the blood accumulates between the cerebral bones and the dura mater, dissecting off the latter in ever-increasing extent, symptoms of cerebral compression finally manifest themselves. But they result more slowly than when the extravasation of blood takes place from the meningeal artery. Yet cases occur, where, owing to the peculiar position of the wound in the sinus, the blood cannot accumulate between the dura

mater and the bone; then, of course, symptoms of cerebral compression are absent.

Schellmann's* experiments show that wounds inthe sinus can heal without their obliteration. Nor does the closure of a large sinus by a thrombus bring about any disturbance in the cranial circulation, provided that there are no continued thrombi nor disintegration of disinfected thrombi with consequent metastatic pyæmia.

Injuries to sinuses of the dura mater, though they present no dangerous or not easily controllable hæmorrhages, may still result fatally because of entrance of air (Volkmann, Genzmer †). *Hæmorrhages from the meningeal artery* usually are brought about by fractures. Either a splintered piece of bone penetrates the vessel, or the vessel is torn when its long axis is crossed by the line of fracture in the bone. But the meningeal artery may also be torn, in simple pressing-in of the bone without interruption of its continuity, because the artery lies bedded in a deep furrow in the bone and is closely united to it by its perforating branches, which enter the bone. This will explain how tearing of the meningeal artery may occur without the application of force directly over the artery. A blow upon the left temporal region may produce a tearing of the right meningeal artery.

The most dangerous, often fatal, hæmorrhages are from the middle meningeal artery, which often yield considerable accumulations of blood within the cranium. If a complicated injury allows the blood to escape outwards, the hæmorrhage might be confounded with hæmorrhage from the deep temporal artery. The real condition in this instance is quickly discernible by dilatation of the wound and finding and ligating the injured vessel.

*Hæmorrhage from the middle meningeal artery* into the skull produces symptoms of cerebral pressure, with continued increase of the symptoms of compression quickly after the injury. Only in exceptional cases was the appearance of symptoms of compression observed after the lapse of some

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* Schellmann, Ueber die Verletzum, gen der Hirnsinus. Inaug.-Diss. Giessen.

† Genzmer, Exstirpation eines faustgrossem Fungus dura matris, tödtlich verlanfen durch Lufteintritt in den geöffneteu sinus longitudinalis. Verhandl. d. deutschen Gesselsch. f. Chirurgie, IV. Congr. 1877. Grössere Vorträge, p. 3.

time. But rarely do these symptoms decrease in intensity. In most instances they become more and more severe.

The initial headache is followed by vomiting, dullness, somnolency, sleep, snoring respiration, and marked slowing of the pulse; the respiration becomes more difficult and labored, rattling in the throat is heard, and death occurs in deep coma. This order of symptoms is often modified and associated with other cerebral manifestations, as, for instance, paralysis in case the injury to the vessels is accompanied by lesions of the brain which most frequently is crushed. In the latter instances the cerebral manifestations occur more quickly after the injury. Symptoms of pressure which follow perhaps eight days after the injury can not be referred to a hæmorrhage of the meningeal artery.

Whenever an injury occurs to the temporo-parietal region with hæmorrhage outwards and rapidly increasing symptoms of brain-pressure, followed by paralysis of the opposite side, we must enlarge the wound, elevate or remove splinters, and proceed to baring the injured artery, be it by the use of a trephine or by enlarging the orifice in the bone with a hammer and chisel so as to reach the artery conveniently, that it may be ligated or compressed. The compressors which were recommended by Von Gräfe for the control of hæmorrhage from the meningeal artery have proven impracticable.

Seeking for the meningeal artery is also indicated in each complicated fracture of the temporo-parietal region, even when no hæmorrhage outwards occurs, whenever marked symptoms of cerebral compression assert themselves, shortly after the injury (Keate, Tatum *). We will be justified in baring the meningeal artery according to Hueter's procedure,† even though the soft parts over the fractured skull be intact, when increased swelling of the temporal region and marked symptoms of compression occur; more so as the unfavorable terminations which as yet have taken place in this interference must be attributed in great part to a neglect of antiseptic precautions. As proof thereof a case of recovery after ligation of said artery was recently reported by Hueter.‡

* Prescott Hewett, Holmes' System of Surg., Vol. II., p. 108.

† Hueter, Virchow. Hirsch's Jahresbericht. 1870. Bd. II., p. 352.

‡ Hueter ein Fall von Heilung einer schweren Schädelverletzung mit Umstetchung der Art. menigea media, Centralbl. f. Chir. 1879, No. 34, p. 553.

The life-saving significance of the above procedure in the almost invariably fatal intracranial hæmorrhages make it appear desirable that *ligation of the middle meningeal artery* be practiced as a typical operation. The procedure is described more in detail by Vogt.*

After splitting the soft parts by an incision ascending about 4 c.m. upwards from the middle of the zygomatic arch, which, however, may be substituted by a crucial incision, or by a tongue-shaped temporal flap, attached to the upper margin af the zygomatic arch by its base and which can be turned down, the lateral cranial wall is exposed, and the periosteum split and levered off. Then the trephine is set in an angle formed by the intersection of two lines, of which one is about 3 c.m. above the zygomatic arch and parallel to it, while the other courses perpendicularly to the first and terminates about 2 c.m. behind the spheno-frontal process of the zygomatic bone. After removal of the disk of bone the artery must be surrounded at both sides of the site of injury. After removal of the accumulated blood we will be compelled to incise the dura mater itself above the district of ligation, so as to free whatever blood may have been poured out between the dura mater and arachnoid. Thorough washing of the wound with three-per-cent solution of carbolic acid, thorough drainage, suture of the wound (when the lips of the wound are clean, or after intentional split of the integumentary coverings), as well as an extensive well-fitting antiseptic bandage must follow.

*Hæmorrhages from the cerebral carotid* have not been observed often. As the artery lies but loosely in the carotid canal of the petrous portion with an expansion of the sinus cavernosus, therefore it is not often torn in fractures of the petrous portion. Beck † describes perforation of the internal carotid by a splinter of bone from the sphenoid. A similar occurence might take place by balls which have penetrated and become fixed in the petrous portion, in time destroying the arterial wall by erosion (Longmore ‡). Nélaton's § case, which has been often cited, certainly is a rarity, showing penetration of a splinter of bone through the cavernous sinus into the internal carotid after a blow on

* Vogt, Deutcshe Zeitschrift, f. Chir. 1872. Bd. II., Heft. 2, p. 165.
† Beck, Die Schüdelberletzungen. Freiburg, 1875. p. 39.
‡ Holmes' System of Surg., Vol. II., p. 87.
§ Démarquay, Traité des tumeurs de l'orbite. Paris, 1860.

the left eye with a stick. An arterio-venous aneurism resulted. The patient died four months later of hæmorrhages from the nose.

*Hæmorrhages between the dura and pia mater* into the so-called sac of the arachnoid occur most frequently by tearing veins which course from the surface of the brain and from the pia mater to the longitudinal sinus. The blood may also be derived directly from the latter. Coincident with them are lesions of the brain and hæmorrhages into the tissue of the pia mater and into the sub-arachnoid spaces.

The cause for the above accumulations of blood are mostly severe injuries, or great displacements of the cranial bones during birth. The symptoms which herein appear refer either directly to crushing of the brain or in case large veins have been torn, cerebral pressure may be developed, though but slowly.

*Fractures of the bony walls of the skull*, which involve either both plates equally, or, as is most frequent, the inner table to a greater extent than the outer, and but rarely affect the inner table alone, may produce a limitation of space in the cranial cavity in various ways. The outflow of cerebro-spinal fluid alone implies a greater venous repletion of the brain with retardation of the circulation. Depressed fragments of bone bring about symptoms of compression, by direct mechanical impingement, more so than do splinters of bone or fractured pieces which perforate the dura mater and are wedged into the brain. Foreign bodies (bullets, knife-blades, etc.), which become imbedded into the brain, conduct themselves analogously to the behavior of splinters. The entity of the manifestations depends upon the amount of lesion to the brain and to that of the intracranial vessels. Hæmorrhages and crushings of the brain are almost invariably found in traumatisms in which the brain capsule is perforated at any part. Thus a depression of bone with coincident extravasation of blood can produce evidences of compression, the existence of which is more clearly established when the manifestations continue, notwithstanding elevation of the bone fragments.

As injuries to the skull have their course determined by the results of the injuries to the brain, so, inversely, does the course of brain-lesion depend upon the condition of the outer wound, and upon the protection against infection, which the latter does or does not receive.

Previous to the introduction of antiseptic treatment of wounds the usual terminations of complicated cerebral lesions were inflammatory œdema of the brain with diffuse extended capillary hæmorrhages, or a continuous septic meningitis, or acute progressive encephalitis, with purulent infiltration of the brain, or an abscess of the brain. Endeavors have been made to demonstrate, experimentally, the purely mechanical influence of bone splinters, or of foreign bodies which have penetrated the brain in the production of the above processes (Fischer's experiments made, by driving nails through the skull near trepanned orifices, etc.*). Doubtless the care of the patient is of importance in determining the course of injuries to the head; it may be summed up in complete psychical and physical rest, avoidance of transportation and permanent application of cold, abstinence from liquids which increase the blood pressure, and enjoining limited diet. But we may safely assume that all the above cited evil terminations are principally subject to the question of infection of the wound. Clinical experiences in this regard show us here as clearly as in other surgical interferences, that the evil results *are dependent upon the course of the wound and not upon the traumatic interferences as such.* It is true that cases have been described wherein fatal traumatic meningitis developed in a cranial cavity which apparently was closed off from the air by uninjured soft and bony coverings. Such descriptions must be accepted with allowance, because even insignificant fissures, which are easily overlooked, especially at the base of the skull, may serve as points of entrance for matters which incite decomposition. Thus we know, according to Weigert's † views that even the intact region of the ethmoidal cells may serve as a port of entrance for infecting matters.

In fact, injuries to the skull which are complicated by insignificant and difficultly discernible fissures, for instance, at the base of the skull, terminate more viciously than do even considerable wounds of the cranial arch which permit easy examination.

Furthermore, those lesions of the skull and of the brain in which there are large intracranial extravasations of

* Fischer, Archiv. f. Klin. Chir., 1865. Bd. VI., p. 595.

† Cohnheim, Die Tuberculose vom standpunkte der Inflections Lehre. Univ.-Programm. Leipzig, 1879, p. 19.

blood take on more serious form. The presence of the latter very early produces strongly marked symptoms of compression. The disturbance of the circulation causes the nutrition of the brain to suffer considerably, as we have seen, so that in these cases every inflammatory irritation, even each hyperæmia, and still more of each inflammatory œdema of the brain, each inflammation of the meninges, or of the brain-substances can the sooner produce conditions which threaten life. On the other hand, here, as everywhere else, septic influences will act so much more rapidly in proportion to the amount of blood, which forms extensive coagula, subject to decomposition.

It was formerly attempted to group scientifically a specific picture of the symptoms which it was alleged were characteristic of contusion of the brain. A large number of these symptoms depend upon sepsis, only that the organ upon which they exert their influence and which re-acts so sensitively to disturbances of nutrition receives a special impress from it. The functional disturbances which the condition of the brain produces in the central nerves of the system, are connected with injuries to certain regions of the brain, after calling forth those manifestations which are dependent upon sepsis.

The experiments of Broca* (centre of speech), the fundamental experiments of Fritsch and Hitzig† on the motor centres of the cerebral cortex, etc., may be used to demonstrate that a diagnosis of cerebral contusion can only be safely made where functional disturbances of certain divisions of the brain can be proven.

However, practically, we have still more important tasks before us, which are, to prevent admission of infectious materials to lesions of the skull and of the brain. This is attainable only *by strictly following antiseptic treatment in all injuries to the head.* Our therapeutics can accomplish but little or nothing after progressive inflammatory processes have been established. In diffuse meningitis, or in encephalitis, or in puriform destruction of brain-substance, in the vicinity of a contusion, in a necrotic focus or abscess of the brain, we are powerless. It is only when inflammatory pro-

* Broca, Sur le siège du language articulé. Bull. de la Soc. Anatomique de Paris, 1861. Bd. IV.

† Fritsch und Hitzig, Ueber die Elektrische Erregbarkeit des Grosshirns, Du Bois' und Reichert's Archiv. f. Physiol., 1870.

cesses are localized and encapsulated, as when cerebral abscesses are sharply defined from their surroundings, that their evacuation can act in a life-saving manner.

It is to be regretted that as yet diagnosis of the site in which a cerebral abscess is developed, is still so difficult and dependent upon accidental circumstances. Many cases terminate fatally in which, had we possessed more exact knowledge of the site of the abscess, the symptoms of compression of the brain could have been relieved, with preservation of life.

When we are called to an injury of the head we must always treat it as if it were complicated with an opening into the cranial cavity. We are caused to do this, though we do not find a perforating fracture of the skull, when brain symptoms, and principally brain pressure, obtain. Our procedures must be more painful when we find a direct fracture of the skull, or when a defect in the bone allows not only the cerebro-spinal fluid to escape, but when brain-matter presents traumatic encephalocele, or wells forth in a comminuted condition.

We first shave the region smoothly to a large extent around the injury, and then thoroughly clean the skin with soap and ether, and assist this procedure with a brush. Thereupon we dilate the wound in the soft parts extensively so that we remove whatever pieces of bone may have penetrated the interior of the skull. We smoothe the margins of the bone with cutting pliers, and endeavor to give it such a form as will allow us facility in viewing the dura matter and the brain, whether one or both of them are injured. It is important to remove all the coagula which have accumulated between the dura matter and the bone, as well as foreign bodies of dirt (earth, sand, powder, etc.), and to wash such bulgings as may present themselves carefully with an antiseptic fluid (three-per-cent carbolic acid solution).

The conditions of the dura mater require special attention. Simple tears and slits must be sufficiently enlarged to permit free evacuation of whatever blood, secretions and pus may have accumulated between the dura mater and the arachnoid. Brain-masses, that have been crushed bodily, are suffused with blood and converted into a loose pasty mass, may be washed out. If decomposition has begun in the brain wound we need not hesitate to paint it thoroughly with an eight-per-cent solution of chloride

of zinc, according to the very encouraging experiments of Socin.* Such painting may be in place also after the evacuation of cerebral abscesses. So we need not hesitate to insert a disinfected drainage-tube into wounds of the skull and even of the brain, through which to conduct the secretions from the wound.†

When the soft parts are lifted off in a flap-like form, the wound may be closed by sutures as far as the drainage tube, as when the soft parts are not severely crushed or do not appear mortified, such sub-cutaneous recesses as occur may be drained. When they have been rendered entirely aseptic, primary adhesions of the flaps of skin with the deeper soft parts may be accomplished by antiseptic compression. The latter must cover the entire extent of the region of injury or operation and considerably beyond it. When applying carbolized gauze the wound must be well covered by compressed layers of the dressing closely pressed together, and the margins of the bandage must be bolstered with salicylated cotton. The application of carbolized jute is well adapted for dressing the surface of the head.

The ideal of antiseptic treatment of complicated injury to the brain is secured in the cure of spontaneous hæmorrhages, frequently with extensive comminution of the brain-mass after cerebral apoplexies. In brain injury as well, efforts must be made for the removal of extravasations of blood of the destroyed parts of the brain, and such particles of bone which may have been driven into it, thus to produce as small a scar as possible. It affords extreme satisfaction, though we can accomplish this with safety in executing antisepsis, of course, only in quite recen t cases. Bergmann (*l. c.* p. 287) designated these results as "perhaps forever beyond our art."

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* Socin, Zur Behandlung der Kopfverletzungen. Correspondenzblatt f. Schweizer Aerzte, 1876. No. 24.

† In a number of experiments I succeeded not only in healing in disinfected plugs of cork and rubber into trepanned orifices, but also in fixing rubber plates between the dura mater and trepanned orifices. These were about the diameter of a dime, thus closing them. The plates became fixed without at all disturbing the condition of the rabbit. At those sites in which the plate, or the cork, or rubber stopper lay upon the brain, a depression of the brain substance was frequently found. Yellowish flakes of fibrine were rarely found between the plate and the brain: The operations were performed strictly under Lister's rules. The wound was closed in each instance directly by deep mattress-sutures and by superficial sutures.

When processes of decomposition have developed in the wound we will endeavor to accomplish an aseptic result by thorough disinfection. Applications of solutions of chloride of zinc (Socin, *l. c.*) will be particularly in place, as has been mentioned. If the effort does not succeed, the hope of securing an aseptic termination must be discarded. We must endeavor, then, to limit as much as possible the processes of decomposition and their extension in the wound. We will then order antiseptic irrigations with solution of salicylic acid, with acidulated clay with acetic acid, with chloride of zinc and other metallic salts in combination, and extensive application of cold. The antiseptic fluids are to be cooled either by insertion into vessels containing ice or freezing mixtures, or by irrigating the shaved head drop by drop, while it is enveloped in ice-bags. The ice-bags may lie upon compresses, which are maintained moist by the fluid which is used for irrigation.

A further object of the *application of ice* is to reduce or relieve appearances of neuro-paralytic cerebral hyperæmia, which results upon the production of reflex vascular contraction, the manifestations of brain pressure, especially the depression of the sensorium, even sopor. Futhermore the application of ice is particularly efficacious in depressing the temperature in whatever septic fever there may be, and especially in depressing the local temperature. Pirogoff,* when in the Caucasus, applied ice with intercurrent cold douches to the head in gun-shot wounds to that part. Stromeyer,† has well advocated this treatment, and justly showed that they render venesection in injuries to the head unnecessary.

But there are cases in which *venesection* is absolutely required. If our patient be robust or plethoric, as, for instance, a vigorous soldier would be, and if a high-fever temperature with a remarkably slow and hard pulse, and if respiration be superficial, difficult, or even irregular, then we will follow Pirogoff's advice and proceed to venesection, which may be repeated in case the appearances return. In children and in debilitated persons venesection must be substituted by local depletion.

The influence of venesection is easily comprehensible. When evidences of brain compression exist in consequence

* Pirogoff, Grundzüge der allgem. Kriegschirurgie. Leipzig, 1864.
† Stromeyer, Maximen der Kriegsheilkunst. Hanover, 1861, p. 405.

of inflammatory hyperæmia, or even of inflammatory œdema with impediments, especially to the arterial supply, a venesection will act principally by facilitating the venous outflow, upon reduction of the arterial stream in removal of the obstacles which lie in the compressed capillary regions. In those cases where the cerebral hyperæmia rests upon a paresis of the arterial walls, venesection, by reducing the amount of the blood and by reducing the fullness of the heart, brings about a reduction of volume of the relaxed vascular regions. Thereby the intracranial pressure is reduced, and the arterial circulation of the brain will be correspondingly increased through the relief of compressed districts.

Similarly we must explain the action of venesection in apoplexia (sanguinea) cerebri, in robust individuals in which it has long been proven and famed.

Venesection is contra-indicated in weak, delicate, pale patients, or in such as have suffered losses of blood, or when there be weakness of the heart.

The third important helps which must be applied in manifestations of compression of the brain, as well as in general sepsis, is the use of purgatives, rarely in the form of drastics (calomel, with jalap) when a rapid action is desired. Saline purgatives are more recommendable. The patient may be given either one to two tablespoonfuls of Glauber's salts (natr. sulfuricum) or Karlsbad salt (sal. therm. Carolinens. fact.) dissolved in lukewarm water, which, when the patient is unconscious, may be poured directly into the stomach through the œsophageal catheter.

The action of purgatives must be explained by the profuse intestinal secretion facilitating the elimination of septic matters and intensifying the lymphatic flow, and with it the absorption of the cerebro-spinal fluid.

We must consider still another means which has often manifested its saving powers in diffuse septic processes, especially of the serous cavities, of the peritoneum, of the pleura, of the pericardium, and also in diffuse meningitis. It is mercury, which may best be employed in the form of *inunctions of ung. cinereum* (each hour or two one or two grams are rubbed into various parts of the body successively) pushed as far as the production of acute mercurialism. Stromeyer (*l. c.*) considered the appearance of salivation as a frequent sign of salvation. Though we can but surmise how and in what form mercury is absorbed into the

organism (Lassar*) we may follow the practical experiences which have been attained in septic processes (Guthrie, Malgaigne, Traube) and apply this remedy in severe cases; and we will occasionally, though seldom, achieve life-saving results.

It is self-evident that besides antiseptic irrigation, application of ice, purgatives, and inunctions of gray ointment, that we must provide, beyond all, for free outflow of the secretions of the wound. For this purpose we will ofttimes require dilatation of the wound, removal of bone-splinters, enlargement of the opening in the bone, with the trephine or the chisel, in recent injuries. Only when fever and swelling of the wound are present we must avoid much interference, because each mechanical irritation may aggravate the condition of the wound and may facilitate the distribution of septic matter.

Notwithstanding all this, whenever septic processes occur in complicated injury to the skull, we will achieve but few good results, despite all of our cares. The limit of power of our therapeutic measures since time immemorial is best proven by the officiousness with which it was customary to assault and torture those whose heads had been injured. Whenever we meet such officiousness in medicine it is an evidence of limited knowledge and small ability. We owe the simplification of the treatment in the above sad conditions, to experimental investigations which gave us the first clear clues to the character of the processes which occur in disturbances to so complicated an apparatus as is the brain.

More favorable results are obtainable in circumscribed accumulations of pus within the brain, in *limited cerebral abscesses*, but these favorable results obtain only under definite fortunate conditions. Primarily, the condition must not be one of diffuse purulent phlegmon of the arachnoid or subarachnoid. Secondly, the chances are more in favor for opening abscesses which occupy a superficial position over those which are more deeply seated. Thirdly, the diagnosis of the site in which the abscess is formed must be firmly established. Even now this point is attended with great difficulties.

Whenever, in injuries to the head, high fever is associated

* Lassar, Ueber den Zusammenhang der Hautresorption und Albuminurie. Virchow's Archiv., Bd. 77.

with chills, cephalagia, depression of the sensorium, etc., and wherever pus wells out between the bone fragments, we do not hesitate to offer a free exit to the pus by removal or elevation of the pieces of bone which stop the opening. These are found but seldom between the dura mater and the bone, as Pott assumed to be the rule. We find this condition only when a decomposing extravasation of blood lies between the dura mater and the bone. Ordinarily, the pus or the puriform detritus originates from the brain-substance itself. The dura mater is occasionally wedged into the osseous space, and appears over the abscess in either a normal condition or crushed and suffused with blood, or discolored and mortified. Or pus may crowd out through slits or holes in the dura mater. In both cases the dura mater must be freely slit, the abscesses emptied and washed out with antiseptic solutions. It finally must be drained according to the general rules of oncotomy.

The diagnosis of an abscess is much more difficult when it develops behind an intact cranial bone. Then the abscess can be opened only by trepanning the skull at the place where the abscess is presumed to be. In some cases this effort has proven successful (for bibliography see Bergmann, *l. c.*, pp. 294 and 295).

After the execution of trephining for an abscess of the brain and exposure of the dura mater, the usual cerebral motions which are observable in a normal brain, and which depend upon increased temporary repletion of blood, are not seen.

The *cerebral motions* are partly coincident with the pulse and partly with the respiration. Pulsatory cerebral motions are isochronous with the systole of the heart, and depend upon a systolic increase of blood in the cerebral arteries and capillaries. The more marked respiratory cerebral motions occur during expiration.

When the skull is intact, the brain, which is full of blood, recedes from the immobile cranial cover towards the base of the skull, because the cerebro-spinal fluid contained in the large sub-arachnoid space of this region can most easily be displaced. If the skull be perforated at any place, the brain's excursions, which in the intact skull are made towards its base, will approach the trephined site, which has become the point of least resistance. Thus the brain motions become visible. In the same manner we see them at the fontanelles of little children and in open spaces resultant upon

cranial fractures. If a trephined opening be closed with a glass plate the brain motions are no longer perceptible (Donders). This led to the erroneous conclusion that brain motions do not exist in the normal state.

Brain motions are often absent when there is a cerebral abscess. Roser* refers this to a close attachment of the dura mater to the brain, over the purulent focus and not to an anæmic condition of the brain beneath the trepanned orifice, it being compressed by an extravasation of blood or an exudation.

After evacuating the cerebral abscess *prolapsus cerebri* frequently supervenes and may assume extensive dimensions if inflammatory œdema or encephalitis occur. Any interference destined to the replacement, reduction or amputation of the prolapse is reprobated. The most rational course would be to protect the prolapsus with antiseptic dressings in case it becomes mortified, because of strangulation, and threatened with disintegration. Then efforts should be made to confine these processes by sprinkling with antiseptic powders (equal parts of powdered charcoal and salicylic acid), by painting with a solution of chloride of zinc, by antiseptic irrigation, etc.

I wish to call your attention to another general disturbance of the brain functions which gives a similar complexity of symptoms as does brain compression, without the occurrence of direct contraction of the cranial cavity or severe brain lesion. I refer to *concussion of the brain — commotio cerebri.*

Hippocrates, Galen, Celsus, and later, Ambroise Paré, have adhered to this conception to designate disturbances of the brain functions which result from violent forces being exerted upon the skull, as in blows, falls from great heights upon the head, etc., and manifest themselves in material interruption of consciousness or at least an obtunding of the sensorium, in general muscular debility and a reduction of sensibility. To these symptoms there are associated, as in compression of the brain, vomiting, slowing of the pulse, and reduction of respiration; in severe cases sopor, coma and death result. Or death follows immediately after the reception of said traumatisms.

Primarily, all of those conditions which are established

* Roser, Was bedentet das Fehlen der Hirnbewegung bei blossliegender, Dura Centralbl. f. Chir. 1875. No. 11, p. 161.

in complicated injuries of the head must be segregated from the picture of the entity designated as concussion of the brain. Nor must severe crushings of the brain, with extravasations of blood into the cranial cavity, or into the brain-substance itself, even when damage to the bony cranial shell is not provable, be considered in this connection. We must finally eliminate all of the conditions which prevail when great violence has been applied to the skull, and injuries of a life-threatening character have been received in other organs, such as occur in falls from great heights. Carefully made autopsies have frequently revealed such injuries in cases which clinically had been assumed to be concussion of the brain, with rapid fatal issue. This has occurred in severe injuries and extravasations of blood in and about the spinal marrow (Deville), in ruptures of the heart (Prescott Hewett), in a tearing into the kidneys (Bergmann, *l. c.*), or in diffuse fatty embolism of the lungs, kidneys, etc. Recently several such cases have been described occurring after multiple severe bone-lesions, elucidating enigmatical conditions found after bone-lesions which had a rapid, fatal termination.* Similar results are attainable experimentally by moderate injection of fluid fat, not only directly into the veins and the heart, but also by injecting the fat into peripheral lymph-vessels of an extremity.

Only such cases may be added to a pure picture of cerebral concussion, which upon careful autopsy of the entire cadaver, present no severe lesions in the brain or other organs. Slight brain-crushings are often found in concussion of the brain. Though similar and even more extensive brain-lesions are found without the occurrence of symptoms of concussion during life, the slight lesions cannot be considered the prime cause of the cerebral commotio.

Cases of pure cerebral concussion occur without palpable or provable changes in the cerebral substance, though this has been frequently placed in question. The experiments made in this regard have yielded undeniable evidence in support of the assertion.

The views which prevailed as to concussion since Littré's†

* For bibliography compare: Flournoy, Contribution à l'étude de l'embolie graisseuse. Inaug.-Diss, Strassburg, 1878; Wiener, Wesen und Schicksal der Fettembolie, Habilit-Schrift, Breslau, 1879; and Scribla, Untersuchungen über Fettembolie, Deutsche Zeitschrift f. Chir. Bd. XII., Heft. 1 and 2.

† Littré, Histoire de l'Acad. Royale des Sciences, 1705, p. 54.

time, as to a quaking or succussion through the brain-matter, in consequence of the communication of the undulations caused by the traumatism applied to the skull, and transferred to the brain, through it, have been entirely refuted by Gama's experiments, which were considerably modified by the investigations of Nélaton, Alquié* and Fischer.†

Beck (*l. c.*) calls attention to the fact that the most marked disturbances in concussions of the brain point to certain regions of the brain and their affections, thus, especially, the medulla oblongata. He found extravasations of blood in the fourth ventricle in concussion of the brain artificially produced, while Westphal‡ who made experimental blows on the skull, reports numerous small hæmorrhages scattered in the spinal marrow.§

Capillary extravasations of blood scattered over the entire brain have been observed clinically. Sometimes they are entirely absent.

When the entity of concussion is separated into an affection of individual brain-centres it becomes evident that probably the force applied primarily affects certain centres, for instance, those of the vascular nerves, those of the heart and respiration, and that, above all, the primary disturbance of circulation produces a disturbance of nutrition of the other centres, whether by arterial anæmia, venous hyperæmia, or of both in succession. Various reasons can be cited for this.

Above all, rapid recovery in certain cases of concussion seems to prove that there can hardly be a material change within the brain-mass, but that it can have been affected by only a transitory disturbance of nutrition. Beck (*l. c.*) found, upon removing the cranial cover in animals in whom clear symptoms of concussion of the brain were manifest, that the brain was very pale and all of the vessels were strongly contracted. A similar condition was proved by

* Alquié. Étude Clinique et Expérimentale de la Commotion Traumatique, etc. Gaz. Méd. de Paris, 1865.

† Fischer, Ueber die Commotio cerebri, Samml. Klin. Vorträge von R. Volkmann, 1871, No. 27.

‡ Westphal. Berl. Klin. Wochenschr., 1871, p. 461.

§ See also Duret. Notes sur la Physiologie Pathologiquedes Traumatismes Cérébraux. Gaz. Méd. de Paris. 1877. Nos. 40, 59 and 61. In forced increase of intracranial pressure Duret found hæmorrhages into the walls of the several ventricles, especially the fourth; into the aqueduct of Sylvius, etc., which he combines with the disturbances of the various brain functions observed in concussion.

Bergmann (*l. c.*, p. 213) in the background of the eye of rabbits with profound cerebral commotion. Furthermore, all of the records of post mortems made in those dead of cerebral concussion show great repletion of the veins of the brain and those of its envelopments.

Fischer (*l. c.*) compared the action of traumatism in a concussion of the brain to the effect of the experiments of Goltz, made by striking a frog. A rapid spasm of the vascular system after primary irritation of the vascular nerve-centers is said to follow their paralysis, with a general vascular paralysis. The difference between the experiments in which a blow was employed and the gradual influence of a great power upon the skull, may be solved by the fact that in traumatism of the head the sudden crowding of the cerebro-spinal fluid and of the whole brain, suffices as a direct mechanical irritation to produce a rapid excitement followed by a continned paralysis of the brain-centres while in experimenting with blows on the belly, oft-repeated (reflected ?) irritation would be requisite.

The primary arterial cerebral anæmia is followed by hyperæmia in connection with the vascular paralysis, which, however, as has been explained, under compression of the brain, again secondarily retards the arterial flow by the interpolation of large impediments to the capillary circulation. Furthermore, paralysis of the vascular nerve-centres produces a dilatation of the vessels in *all* of the regions of the body with engorgement of blood in them, which implies a deep sinking of the blood-pressure. To the brain in which the arterial flow is retarded, this means, furthermore, that the arterial blood flows through its various regions, not only more slowly, but also in lesser quantities.

Koch and Filehne* in a similar manner endeavored to derive the symptoms of concussion of the brain from a direct mechanical affection of all the brain-centres. Certainly the affection of the vasomotor centres plays a principal part in this connection. We also see in cerebral concussion disturbances of those centres which are most susceptible to anomalies of nutrition, that is, disturbances in the various centers lying within the cerebral cortex, where they are most strongly marked.

The fact that such disturbances of nutrition of the brain-

* Koch and Filehne, Ueber Commotio cerebri, Verhandl. d. deutschen Gesellsch. f. Chir., 1874, III. Congr. Grössere Vorträge, p. 10.

centres really occur in concussion of the brain is again shown very clearly in the cases which terminate in recovery. In these, each of the functions of the brain was restored as slowly, as after profound chloroform narcosis, in which a dangerous asphyxia existed. I would call your attention particularly to the manifestation which Böhm* described in his reports of animals which he had chloroformed almost to death and which he details as manifestations after recovery from apparent death ("Erscheinungen nach gehobenem Scheintod"). This analogy is particularly noteworthy because you know how deeply the blood-pressure can sink for a long time in dangerous chloroform narcosis.

We distinguish, in cases of cerebral concussion which do not terminate fatally, between light cases and severe ones. In both, the principal symptom is unconsciousness lasting for a lesser or greater length of time.

In the lighter cases the patient breaks down with a sensation of giddiness, glittering before the eyes, and whirring in the ears. His face becomes pale, the eyes become fixed and non-responsive. The respiration appears flat, the pulse filiform and barely perceptible. Soon the patient recovers and complains only of headache, debility, languour and tingling in the ears. Sometimes various subsequent disturbances of the motor sphere appear, thus as in the movements of the eye; there also may be stammering or, at least difficult articulation. Permanent disturbances of the various co-ordinate movements, as grasping, etc., are particularly worthy of attention. Diabetes mellitus and insipidus, and albuminuria have been observed after concussions of the brain.

The symptoms of severe cases of concussion of the brain are more complicated. Unconsciousness is absolute; the injured person does not respond to strong irritations. The pupil contracts but slowly upon the approach of light, but frequently swallowing takes place upon fluids being poured in. The features are deadly pale and collapsed. The body soon becomes quite cool. The pulse is intermittent, small, and often slow. Urine and fæces are retained or are passed unconsciously. Vomiting often follows later on. After the lapse of hours or days an improvement occurs. Respiration becomes deeper, the heart and pulse beat more

* Böhm. Ueber Wiederbelebung nach Vergiftung und Asphyxie, Archiv. f. experim. Pathol. und Pharmakol., Bd. VIII., pp. 68 to 101.

fully and strongly, the bodily temperature rises, voluntary motions again are made, and finally consciousness returns.

Most frequently the general depression is followed by a stage of excitement. The temperature of the skin rises, the pulse becomes hard and frequent, the face is flushed, the pupils are contracted and the eyes glisten.

Furthermore, when true meningitic manifestations are developed, then a pure concussion has not occurred, but a complication with evident injury to the skull and brain has taken place. We must assume the same when the comatose condition continues very long, or when the sopor becomes more profound, also when convulsions or paralyses of certain regions occur. This issue has been noted particularly in concussion with co-incident fracture of the base of the skull.

Though the patient recovers rapidly after concussion of the brain he may by no means be removed from medical supervision. Sometimes serious manifestations occur later. Sudden symptoms of compression of the brain may appear when the extravasations of blood within the skull become enlarged, or when a not diagnosable crushing of the brain gives rise to the appearance of general inflammatory processes in the brain and its coverings.

The *treatment* of cerebral concussion must be purely symptomatic. The depression of the blood-pressure requires the application of means which would elevate it, among which irritations to the skin play an important part. Perhaps autotransfusion, by depressing the head lower than the body, may prove efficacious. Repeated subcutaneous injections of ether (a Pravaz syringe-full, about a gram, at a time) have been recommended. Large doses of musk should be given internally when the patient can swallow. Particular provisions should be made against the reduction of the bodily temperature by enveloping it in warm cloths, and the application of hot bottles to the body of the patient as well as long-continued warm baths.

Beyond all, the hair should be cut or the head shaved, and carefully examined for whatever injuries there may be. If later on inflammatory manifestations occur they must be treated as has been detailed above.

In the discussion of therapeutic measures in contractions of the space within the skull, such as are dangerous to life, and in injuries to the skull, we have noted that *trephining the cranium* has given us some indications which incite us to devote some remarks to this operation.

For centuries the applicability or non-applicability of this operation, which was well known and practised by the oldest nations, was widely discussed. The most extreme views prevail as to the applicability of trepanning in all complicated injuries to the head (prophylactic trepanning —Pott), while others have advocated its complete elimination from surgical practice (Textor, Dieffenbach, Malgaigne, Stromeyer).

In general we find that the more complete the surgical school the rarer the trepan was employed. Even those who saw their patients die with injuries to the head, notwithstanding trepanning more frequently, yet in consequence of it they rescinded more and more from the employment of the operation.

At all events we may consider *prophylactic* trepanning in recent injuries to the head as definitely set aside. We substitute it by carefully-executed antiseptic cleansing of the wounds and subsequent antiseptic occlusion, just as we have ceased to make primary resections of the joints in recent injuries to them, as was done especially to favor conditions to guard against the inroads which suppuration, established within the synovial cavities, would make. This process usually established itself when antiseptic precautions are not employed.

Exploratory trepanning for the purpose of extracting foreign bodies, or to find abscesses which had been formed within the brain and evacuated, has recently suffered much limitation. In foreign bodies we will trephine only when they are wedged into the cranial parietes and can not be removed without the bony substance that surrounds them (such as knife-blades, ramrods, etc., which are wedged into the bone). Exploration for foreign bodies that are not visible, especially bullets, is reprehensible as long as there are no cerebral manifestations indicating the presence of the foreign body, or inflammations or suppurations produced by it. The absence of a wound of exit in gun-shots to the head does not justify the assumption that the bullet lies within the cranial space. Despite the firm assertions of the patient or of other witnesses, the force of the ball may have become spent after the concussion and production of the depression in the bone, and may have simply fallen to the ground. As to the value of exploratory trephining in abscess of the brain we have repeatedly expressed ourselves. A more concise knowledge of the localization

of the individual brain functions will give us definite points of departure in the future.

Therefore we will proceed to trephining, that is, to the removal of a firm piece of bone from the continuity of the cranial roof; *first*, for the purpose of enlarging the space in the bone through which to extract splinters of bone or foreign bodies that are difficult to move or grasp; *secondly*, for the purpose of ligating the injured middle meningeal artery in case it cannot be tied in the wound; *thirdly*, to remove blood from the skull or masses of pus from the brain substance.

When there is no fracture of the skull we trephine only to remove such a piece of bone into which a foreign body has been firmly wedged; furthermore, for the purpose of ligating the middle meningeal artery when, notwithstanding slight damage to the bone there are clear symptoms of hæmorrhage from this artery, and, finally, for the purpose of evacuating abscesses which have been diagnosticated in certain regions of the brain.

We will begin, in describing the typical procedures, by those of *boring out the bony disc from the intact cranial arch.* We alluded to it in discussing the procedures for ligating the middle meningeal artery.

After splitting the skin, the soft parts, and the periosteum, we arrive immediately upon the bone, which we free by levering off the periosteum to a sufficient extent. The disc of bone is bored out by means of the crown of the trepan; a metal cylinder, the under margin of which is provided with saw-teeth. Its upper closed end is continued in a hollow axle into which a rotary curved, or a diagonal handle is fastened by means of which the crown can be given a rotary motion upon its axis. The first combination is called the *arched trepan* (Bogen trepan), when a diagonal handle is used the combination represents the *trephine* or *hand-trepan.* The cylindrical saw might slip when placed upon the arched surface of the cranial roof, therefore these instruments carry within their cylinder a spear, called the pyramid, which may be moved upwards or downwards. This pyramid is allowed to project over the free, toothed-edge of the crown of the trepan, and is inserted into a small hole which has previously been made by the perforating trepan (a hand trepan with a heart-shaped point) or with a gimlet. If the spear penetrates sufficiently deep into the hole prepared for it, the teeth of the crown of the trepan gradually en-

croach upon the bone, forming a disk, which is to be removed within the furrow which the saw-teeth produce. Then the pyramidal spear, within the cylinder of the trepan, is drawn upward so as to facilitate further sawing. Before the bony disc has become entirely movable a screw must be fastened into the central hole to form a sort of handle with a corresponding quadrangular opening at the upper end of the screw. The hook or lever with the screw bear the collective name of Tirfonds. In emergencies this may be substituted by a pointed elevator, or a chisel, to be used as levers, or *Brun's sequestrum pliers.* When every preparatory production of a hole within the bone disc is impossible, as when the middle of the disk is a movable fragment of bone which lies within the depression, slipping of the crown of the trepan must be prevented by pressing metal rings with lateral handles (crown holders) upon the skull, and rotating the crown of the trepan within their open space. Perforated discs of pasteboard, leather, and wood have been used for the same purpose.

During the sawing a sound should be inserted from time to time in the furrow, to elicit whether it is equally deep in all its parts. When this is not the case, further motions of the crown of the trepan must be depressed more towards the side at which it has not as yet penetrated as deeply as it did on the other. This is one of the reasons for the *preference of the hand trephine over the arched trepan,* because the former allows perforation with greater delicacy. If, after the disc of bone has been removed, the trephined orifice shows a rough margin or projecting bony points, especially towards the cranial cavity, they must be smoothed off with an appropriate instrument (*linsenmesser:* lentil-knife), a chisel, the sides of which are sharpened, but the point of which is blunted by a flat, lentil-shaped button, which occupies a diagonal position to it. The button is placed between the bone and the dura mater, while the knife is rotated upon its axis and its sharp edges pressed against the uneven bony margin, so as to cut it or scrape it smooth. Luer's rongeurs are very handy for the removal of projecting points of bone, or for rounding off toothed projections within the margin of a space in the bone. It were well to have several of these instruments, of various sizes, on hand. For the removal of splinters of the inner plate which have slipped under the margin of the trepanned opening, between the dura mater and the bone, Bruns' long pincettes,

with doubly crossed legs and scoop-shaped ends, are very useful. These forceps are either straight or bent to an angle on their flat surfaces.

Wherever the purpose is not to produce an opening in the intact cranial roof, but to enlarge or round off traumatic defects in the bone, as in splintered fractures, etc., the use of the hammer and chisel deserve preference over trephining instruments, as being more conveniently managed (Roser*). It is equally recommendable to remove foreign bodies which are wedged into the cranial bone (projectiles, knife-blades, etc.), with a chisel, a safer procedure, which entails less injury than does the removal of a disc of bone. The fear of the production of fissures by the use of the chisel is as little justifiable as is the fear that the use of the chisel would produce necrosis of the margins of the solution of continuity. The chisel which is employed should be preferably sharpened on one side, such as sculptors use, instead of the wedge-shaped, thin blade which is usually employed. Experiments made on other bones of the skeleton, of which large numbers are now recorded, because of the increasing frequency with which osteotomies and similar operations are now made, have also contributed their share to relieve the prejudice against the use of the chisel, and have established *its unqualified preference over the saw.* The long bones have also been trephined through the diaphyses in infectious osteomyelitis, so as to wash out the ichorous medullary substance through the trephined opening, to disinfect it, and to drain the osseous canal.

Trephined openings heal but slowly, as do all fractures and fissures of the cranial roof. According to Kosmowski's † experiments, the principal proliferation proceeds from the opened medullary spaces of the diploë. The new formed (osteoid) connective tissue yields, directly, bony substance, which radiates from the periphery of the hole into the fibrous connective tissue, which closes the opening. This, however, occurs in but a defective way.

In the beginning, the brain crowds the dura mater into the opening, and manifests clearly perceptible pulsations. But gradually the connective tissue cicatrix in the trepan-

* Roser, Archiv. f. Heilkunde, 1867, p. 553.

† Kosmowski, Heilung von Trepanationswunden, St. Petersburg, 1871 (in Russia).

ned hole becomes so firm and callously tough that the brain-pulsations are not transmissible through it, although the formation of bone in it is but incomplete, occurring only in the form of bony islets.

In larger solutions of continuity of the skull, especially in necrosis of the bone (for instance in syphilis), the scar is more resilient, allowing perceptible brain-pulsations to persist for years. Owing to the danger to which such patients are exposed in cases of repeated traumatisms to the head, they are ordered to wear protectors, which have inserted into them correspondingly curved and padded metal or leather plates, to cover the defect in the bone or the hole produced by the trephine.

It is said that efforts to heal in the discs which had been removed have succeeded in isolated cases. According to the experiments of J. Wolff,* success in this regard is materially facilitated when a bony flap is lifted up, cover-like, and its base allowed to remain in connection with the cranial roof by periosteum, and subsequently re-inserted into the opening. This procedure has, as yet, not been practically applied.

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* J. Wolff, v. Langenbeck's Archiv. Bd. IV., p. 250, u. ff.

## LECTURE XII.

*Aids in accidents to masses of men.*—SURGICAL AID IN WAR.—*General considerations.—Objective points of military surgery.—Task of each individual surgeon.—Information requisite.—Leading principles in military practice.*—THE BATTLE-FIELD.—*Division of the wounded into those who are capable and those who are incapable of marching.*—PLACES FOR IMMEDIATE DRESSINGS.—*Selection of place.—Refreshment for the wounded.—Classification of injuries.—Provisional arrest of dangerous hæmorrhages.—How should the primary dressing be made?—Antiseptic compresses, bandages, cloths, slings.—Splints, their improvisation.—Stretchers.—Means of transport from the battle-field.—Medical staff.—Carriers of the wounded.—The place of permanent dressing.—Only for the wounded who cannot march. The medical staff and its organization.—Organization of the sanitary detachment.—Consulting surgeons.—Assortment of the wounded.—Tickets.—The diagnosis cards formerly employed.—Dressings for those to be immediately removed.—Injuries belonging to this class.—Form of dressing.—Drainage.—Course and contents of the canal of the shot-wound.—Splints, ready-made and improvised.—Means of transportation from the dressing-station to the field-hospital, to the depot, and to the sanitary train—Improvisation of these means of transportation.—Injuries in which operative interference is requisite.—No resections to be performed at the dressing station.—Injuries which cannot bear transportation.*

GENTLEMEN: You will comprehend that, if we should be required to compress within the limits of a single lecture every fact of value for your work as military surgeons, no exhaustive presentation of the subject, but only the leading principles in their general outline, could be set forth. It is, however, not our task to add one more to the numerous works on military surgery to which the last two belligerent decenniums have given rise. You will merely obtain in the labor of the surgeon in war time an example of how

and when you are to apply, or to modify, the rules for assistance which you have learned to employ in saving the life of a single individual, whenever it should be your lot to have to do with serious conditions occurring among larger bodies of men.

A glance at the history of military surgery shows that, among various nations, greater attention began to be directed to the care of the wounded, at the time when these nations had arrived at a certain rather high degree of civilization.

In regard to the requisites which are here involved, the closest approximation to their fulfilment yet made was in the last Franco-Prussian war (1870–71). And as the final result of all labors directed to this end two problems have originated, whose solution must be sought for in our future way in history by every possible means, if we wish to attain any real progress in the domain of military surgery.

The first problem implies the task of combining the most earnest endeavors for the care and treatment of the wounded in war time, with the maintenance, hitherto neglected, of the hygiene of soldiers in time of peace.

In the way thus marked out, Saxony alone has outstripped other nations by the establishment of the Albertopolis in Dresden, thus setting an illustrious example. The application and further extension of the results thus obtained must be left by civil and military authorities alike to the army surgeons.

For you, gentlemen, who, as practising physicians in every-day life are called upon to act among greater and smaller communities of people, the second problem is of far greater importance. For the second problem depends upon the task of ADVANTAGEOUSLY ORGANIZING THE VOLUNTEER CORPS OF NURSES FOR THE WOUNDED, AND OF MAKING THEM SERVICEABLE TO THE WIDEST POSSIBLE EXTENT.

Here is the field in which you, as scientific experts and advisers of the self-sacrificing multitude, must regulate the correct division and application of the forces at your command.

In order to be wholly quit of these claims upon you, certain prerequisites are necessary, namely :

1. Acquaintance with the sanitary establishment of the army in time of war. As is evident, we cannot here enter upon this subject.

2. Acquaintance with the duty of the physician in time of war, either

(*a*) Upon the battle-field.
(*b*) At the place for immediate dressing.
(*c*) At the field hospital.
(*d*) At the depots and in the hospital at home.

3d. Acquaintance with the means of transportation from the battle-field to the place selected for temporary dressing and the field-hospital, from there to the depot, and from the latter home (land, water and railroad transportation).

Only a few of the above categories can form the subject of a more intimate inquiry.

In the first place, it appears of importance to establish the general standpoint, which can serve us as a guide to our duty as physicians in war. Briefly summarized, this is as follows:

1. Correct division of labor among the assistant force.
2. Immediate assortment of the wounded, according to the severity of their injuries.
3. Rational attention to the immediate shelter and care of the wounded. (Removal to buildings, sheds and tents; feeding.)
4. Immediate dressing, with special reference to the subsequent antiseptic treatment and to transportation.

4th. Suitable adaptation of matters at hand (soldiers' clothes, weapons, furniture in dwellings, vehicles in cities and in the country, etc.), to form improvised materials for dressing, lodging and transportation.

After the above remarks it will be clear to you that it is the work expended on the battle-field and at the place of temporary dressing which appears the most important and the most laborious. Moreover, it requires a very particular consideration, because it is in many respects so different from surgical practice in times of peace.

### THE BATTLE-FIELD.

Here the task for the sanitary service consists in the *transportation of all of the surviving wounded* to the place of immediate dressing or to the field-hospital. The wounded, accordingly, are simply to be separated into two chief divisions.

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* Knorr, Ueber Entwickelung und Gestaltung des Heeres-Sanitäts wesens d. europäischen Staaten. Hanover, 1878 u. 1879. 6 Hefte.

(*a*) Those capable of marching, to be transported to the field-hospital.

(*b*) Those incapable of marching, to be transported to the place for temporary dressing.

In order to be able to conduct this *classification upon a large scale*, certain places of rendezvous (places for dressings of urgent necessity) should be located upon the battle-field itself, out of the range of musket-fire, if possible, and marked by the sign of the Geneva Convention—a red cross on a white field. If possible, a plot of ground should be chosen, with a shady group of trees, perhaps, too, with a brook or a shed; at all events, a place should be selected where a tent can be pitched for the severely wounded.

The first duty at the place for urgent dressings must consist in the administration of cordials and stimulants to the wounded. Next, we shall have to direct our chief care to the assortment of injuries for the application of dressings. Of operative procedures, the only one which can come into question is the provisional arrest of hæmorrhages of sufficient magnitude to threaten life.

In what way should the first dressing be constructed, upon the field of battle?

In modern warfare, gun-shot wounds preponderate over all other forms of injury. Thus, in the campaign of 1866, the wounds in the Prussian army* of 13,202 cases, 79 per per cent were by gun-shot, 16 per cent by shells, while the injuries from sabres and lances formed only about 5 per cent, and by bayonet about 0.4 per cent. Still more apparent are the relations in the statistics of the war of 1870–71.† Here the entire loss of the Prussian army amounted to 65,610 men, 86 per cent of whom were from gun-shot wounds, and 7.8 per cent from injuries produced by large shot and splinters of shells. If, in addition, we subtract .4 per cent for injuries in which an accurate designation of the weapon inflicting them is lacking, the remainder accounts for wounds which were due to the sabre-cuts, blows from the butts of guns, bayonet or lance thrusts, in-

* Militär-Wochenblatt, 1867, p. 244.

† G. Fischer, Statistik der in dem Kriege 1870–71 im preussischen Heere vorgekommenen Verwundungen und Tödtungen. Berlin, 1876; p. 6.

‡ Esmarch, Die antiseptische Wundbehandlung in der Kriegschirurgie. Verhandl. des V. Congresses d. deutsch. Gesellsch. f. Chir. I., p. 13 to 17 (Discussion), and II., p. 104.

juries from fragments of stone and earth, and from explosions of mines, as well as burned wounds.

Since we have, therefore, to deal chiefly with shot-wounds, produced by the action of projectiles from small arms, our attention in the application of immediate dressings must be chiefly, and with especial regard to the attainment of aseptic conduct of the wound, directed to the prevention of the entrance of all impure substances which could excite decomposition within the wound.

As the first protective measure, in a negative sense, is to be regarded the limitation, as far as possible, of digital examination of the wound, in case the finger cannot be amply disinfected, which is only rarely possible on the battle-field even under most favorable circumstances. In opposition to the indication which, even at the beginning of the Franco-German war, was still enjoined upon surgeons to acquaint themselves as early as possible with the nature of the injury by the introduction of the finger into the recent wound, we must now emphasize the necessity of entirely omitting the primary examination of wounds, provided no dangerous hæmorrhage is present, and of renouncing an accurate diagnosis in favor of an antiseptic treatment of the wound. In this method of treatment we are confirmed by the observations, continually increasing in number, of shot-wounds healing by first intention, either under a slough or under the employment of antiseptic precautions. (Stromeyer, Pirogoff, v. Langenbeck, Volkmann, Fischer, Socin, * Klebs.†)

To this end, we must cover the orifices of entry and exit with substances which, on the one hand, render any direct contamination of the wound impossible, and, on the other hand, contain so much antiseptic matter that, in case the soiling of the materials used for dressing is unavoidable, decomposition could not possibly take place among the impurities which had penetrated into the dressing. The significance of the antiseptic material in the dressing, as affecting the secretion of the wound, is a consideration of secondary importance; since, at most, it is only in wounds which go to the field-hospital for further treatment that the primary dressing remains on any length of time. In the

* Socin, Kriegschirurgische Erfahrungen. Leipzig, 1873; p. 6.

† Klebs, Beiträge zur pathologischen Anatomie der Schusswunden. Leipzig, 1872; p. 50, et seq.

other wounds which come to the place of immediate dressing, it has only the significance of a temporary protective.

It will be readily understood by you that we can employ only a relatively small amount of material for dressing, and hence it follows that the antiseptic substance with which the dressing is impregnated should be distributed uniformly and in undiminished quantity through the latter. Just here lies a difficulty which, up to the present day, must still be regarded as unsolved. It has been proposed to use for these immediate dressings compresses of jute (balls of jute attached to strips of gauze), which have been impregnated with carbolized resin, salicylic acid, or chloride of zinc, then the compresses are to be applied to the wound and secured by bandages or cloths. The compresses, with a bandage or triangularly-shaped piece of cloth, wrapped in water-tight paper (Esmarch, *l. c.*), should be distributed to each soldier, and either carried in the knapsack or attached to a certain part of the uniform, so that every soldier, if need be, can apply an immediate dressing to himself or his comrade.

It will be more important and more advantageous to provide a certain number only of soldiers, and particularly the hospital aids, who have been detailed beforehand for sanitary service, with a greater number of specially packed compresses of the sort above mentioned. And this on the score that the compresses which each soldier carries around with him in his knapsack or on his clothes, and which share in all the exposures to which the latter, especially the uniform, are subject, can only with difficulty retain the properties of cleanliness and antisepsis which are required of them.

Carbolic acid above all, as a volatile antiseptic, will very quickly evaporate, as we know from investigations in regard to the amount contained in the carbolized bandages prepared after Lister's directions by Münnich and P. Bruns.*

Again, the compresses recommended by Esmarch, of salicylized jute, in which the relative non-volatility of salicylic acid was brought into account, have not, according to the experiments made by the Prussian Ministry of

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* Kaufmann, Centralbl. f. Chir., 1879, No. 50; also Münnich, Deutsche militärärztliche Zeitschrift, 1880; Heft 2, p. 47–81.

War, proved satisfactory.* Since it is not possible to unite salicylic acid intimately with the jute, the former is deposited in the form of crystals, and these are found among the surrounding articles, along with the jute compresses, which have been deprived of their salicylic acid and are not antiseptic, and this if the soldier's coat has been shaken but a few times. Chloride of zinc, too, falls out in the form of powder.

While, then, we insist upon the principle of the antiseptic compresses, we must wait to see whether it is possible to saturate them with an antiseptic which will preserve for a long time its antiputrefactive properties.

In the wounded who are capable of marching, who for the most part will have slight wounds of the head and upper extremities, the retention of the compresses is secured by bandages or cloths. For the support of the arm with slings, we use large, triangular pieces of cloth. In case of necessity the slings can be improvised from the sleeves and skirts of coats.†

If possible, canteens filled with strengthening drink are distributed to the bandaged warriors.

In regard to the wounded who are not capable of marching, in whom, for the most part, injuries of bones in their continuity are present, we will, during their transportation to the place of permanent dressing, apply of course the same antiseptic compresses; but, to enable them to undergo the necessary transportation, splints must also be applied, which will secure in place the ends of the fractured bones.

Such splints can be improvised out of weapons—bayonets, scabbards, and even out of branches, straw, straw-mats, saddles, cloaks, etc. In the transportation, which for the most part will be accomplished by hand-bearers, on stretchers or litters, the knapsack will be used as a cushion. (Details will be found in the admirable work already cited, the "Hand-book of the Practice of Military Surgery," by Esmarch, which must be most earnestly recommended to every young surgeon for study.)

The stretchers themselves are covered with drilling or sail-cloth. More rarely will it be possible to carry on

* Verhandl. des VIII. Congresses d. deutschen Gesellschaft. f. Chir. 2. Sitzung vom 17 April, 1879; p. 47 et seq.

† Esmarch, Handb. des Kriegschirurg. Technik., 1877; p. 58.

transportation to any great extent in ambulances, and still more rarely in contrivances slung from the saddles of horses or mules.* Stretchers can also be improvised from stakes, or branches of trees (Smith†) with cross-pieces and covered with straw-matting. Short ladders, also guns with coats spread over them, etc., are applicable.

As already mentioned, the only one among surgical operations to be employed upon the battle-field is the provisional arrest of hæmorrhage with the tourniquet, or better still, the elastic bandage (after the plan of Esmarch and Bardeleben).

In regard to the *personnel* necessary for the removal of the wounded from the battle-field, it is to be remarked that we need only a few physicians at the place of immediate dressing, whose chief duty will consist in the assortment of the wounded. For the application of the primary dressing, a pretty large number of hospital aids is sufficient.

A greater number of men to carry the injured is required. To them shall be assigned, under military direction, the removal of those of the wounded who are incapable of marching. When, besides, there is a great number of the wounded who can be readily transported, the aid of volunteers to assist in carrying the injured may come into consideration, but only under the proviso that these latter shall be subordinated to expert military direction.

### THE PLACE OF PERMANENT DRESSING.

This forms the first halting-place beyond the battle-field for the reception of those already incapable of marching, or those who would become so in the process of transportation from the battle-field to the field-hospital. The position of the place for permanent dressing must be as secure a one as possible, and yet easily discoverable and accessible from the battle-field.

For reception in the place for permanent dressings, then, only those of the wounded should come who are incapable of marching, and they should be classified directly, accord-

* H. Fischer, Allgmein Kriegschirurgie, p. 301. Handb. v. Pitha u. Billroth.

† Smith (Norway), Nogle nye Transport midler for Saarede. Kristiania, 1876; compare also Mühlwenzel, Internat. Ausstell. f. Gesundheitspflege, etc. Brüssel, 1876. Feldarzt, 1876, Nos. 22, 23, and 24.

ing to the severity of their injuries, into the following categories:

1st. Those who are to be transported immediately to the rear, after application of a dressing suitable for the journey.

2d. Those who are capable of removal to the rear after several hours' rest, or after the performance of the requisite operations.

3d. Those unsuited to transportation.

The classification of the wounded at the place of permanent dressing is the most difficult, and, to the wounded, the most important part of the physician's duty. In great measure it decides the future fate of the injured warrior. This duty must, therefore, be assigned to experienced hands, well schooled in military surgery.

The surgical force should not, as has been so often done hitherto, be massed upon the battle-field, without being able to develop a profitable activity. It is expedient, therefore, to have ready, at the place of permanent dressing, a large medical corps, which, divided into sections, will be able to carry out their varied and extensive labors.

This is not the place to describe more exactly how the medical staff necessary for an action should be organized for the sanitary detachments to whom the work at the place of permanent dressing is allotted. The experiences of the Franco-German war have afforded ideas something like the following:

1st. Doubling the sanitary detachments for each army-corps, so that in every case one sanitary detachment shall be assigned to each brigade. 2d. Diminution of the permanent medical staff of the sanitary detachment from 7 or 8 physicians to at most 3 physicians. 3d. Separation of the companies of men detailed for carrying the wounded, from the sanitary detail, so that each half-company shall, under the command of a lieutenant and the medical supervision of an assistant physician, be directly subordinated to the brigade. 4th. The command and supervision of the sanitary detachment should be assigned to the physician-in-chief. 5th. Omnibus-wagons should be provided for the transportation of the subordinates in the sanitary detachment (hospital-aids, nurses), and these again can be used for the transportation of the wounded to the place of permanent dressing, when the sanitary detachment is in course of establishment. In this way the mobility of the sanitary detachment as a whole, and the efficiency of its subordinates, when it is in working order, are increased. 6th. The ambulances are to be assigned to the companies, or rather half-companies, of the carrier-corps. 7th. Besides two pack-wagons (one for the physicians, the other for the subordinates), the sanitary detachment should carry along with it (*a*), an operating-wagon, containing an operating tent, operating table, instruments, antiseptic apparatus, and apothecaries' stores (consisting of a large stock of carbolic acid, smaller quantities of chloroform, chloride of zinc, two per cent. car-

bolized vaseline, morphine for subcutaneous injection, castor oil; also still smaller quantities of the preparations of opium for internal use, and sodium sulphate, and small quantities of the liquor ferri sesquichloridi, argenti nitras, tinctura sem. strychnin, tannin, croton oil, bicarbonate of sodium, tinctura quininæ comp., etc,). (*b*). A dressing-wagon, with all the materials for an antiseptic dressing, carbolized jute, salicylized cotton, mull and gauze bandages, and flannel and linen bandages impregnated with chloride of zinc, splints and splint-materials (see below), water-proof textures (pressed rubber, oiled paper), adhesive plaster, rubber rings for extension, ice-bags. Finally (*c*), a commissary-wagon, containing pea-sausages, preserved meat, rice, liquor, wine, coffee and sugar. 8th. In case of action, the physicians attending the troops and the physicians of field-hospitals which are not on duty, may be detailed in accordance with the demands of necessity or the requirements of the surgeon of division or the corps-surgeon, to a sanitary detachment for the time, in which the latter is in operation. 9th. While the sanitary detachment is in active service, the consulting surgeon assigned to the brigade or the division takes command of it, being represented by the physician-in-chief of the sanitary detachment. (Compare also V. Scheven, Deutsch Militärärzt Zeitschr. 1877, Heft 6, p. 265.)

AT THE STATION FOR DRESSING, MOREOVER, IS THE SPOT WHERE THE MOST EXPERIENCED SURGEONS, EVEN IF FOR A TIME ONLY, MUST PUT THEMSELVES AT THE HEAD OF THE REST OF THE MEDICAL STAFF.

Here they will be able to make all their knowledge and ability available to the very fullest extent. Here, where the fate of hundreds and hundreds is decided, their counsel and judgment can be of especial service, perhaps more than in the field-hospitals and military depots, where the consulting surgeons, for the most part, have only to enter upon the after-treatment, and that often to the discouragement of those who, for weeks and months previous, have carried on in the most careful manner the medical treatment of the patients entrusted to their charge.

The first duty of the head-surgeon, at the place of dressing, consists in the division of the medical staff into four sections, according to the individual capacity of each physician. As we shall see, a special duty is assigned to each one of these sections.

The surgeon himself takes his place at the head of the first section, and in connection with it undertakes the assortment of the wounded as they are from time to time brought in to the place of permanent dressing. Differently colored tickets are now attached to the breasts of each of the wounded, to distinguish them most readily, according to the categories which have been already given. These tickets should have printed on both sides a single word to

signify the different divisions. Thus, on the yellow card the word "Immediate" can be printed; on the blue card, the words "To wait;" on the red card, the words "To remain."

Previous to the present time, in place of the tickets here recommended, the so-called "Diagnosis cards" were introduced and distributed in great numbers among the physicians. On these cards the physicians were to designate, as accurately as possible, the result of their primary examinations.

These cards take their origin from the time when primary digital examination of wounds was strenuously enjoined. It must be laid to the charge of these cards and of the desire to make as accurate and correct diagnoses as possible, that fingers have been thrust into so many wounds which, without this exploration, might have healed without delay. Blood, rain, or dust often render the hastily written and scarcely legible characters indistinguishable. The diagnosis-card was written to no purpose, and to no purpose was the life of the wounded man sacrificed.

The different colored cards which are recommended, have the object of facilitating, at the dressing-station, only the supervision of the assortment and grouping of the injured.

The second separate medical section has to do with that division of the wounded who, after the application of a dressing suitable for the journey, are to be conveyed directly to the rear. In this division belong all injuries (of soldiers incapable of marching) which require no immediate operative interference; more particularly all shot-wounds of the soft parts, all shot-wounds of the joints, and all wounds produced by shots glancing off without solution of continuity of bone. So, too, shot-wounds of the lungs, without hæmoptysis, and wounds of the abdomen, without intestinal prolapse.

In all these cases, the region of the injury is to be carefully cleansed, and a Lister dressing (if possible under the carbolic spray) applied; and for this purpose we will employ carbolized jute (Münnich*), or dry jute saturated with chloride of zinc†, either in the form of flat layers or of

* Münnich, Ueber die Verwendbarkeit, etc. Deutsche milifärärztl. Zeitschrift, 1877. VI. Jahrgang Heft 10.

† Köhler, Ber. über die Klinik von Bardeleben pro 1878. Charité Annalen, 5 Jahrg. 1880, p. 563.

cushions packed in sacks of antiseptic gauze.* Here, too, the carbolized gauze prepared by P. Bruns† in the cold way might be employed. The securing of the antiseptic dressing is accomplished on the extremities by the aid of simple, starched gauze bandages, moistened with a 3 to 5 per cent solution of carbolic acid; on the chest, abdomen, shoulder and hip, with the addition of a few strengthened bandages of gauze, or flannel, or linen bandages, which have been previously impregnated with a 10 per cent solution of chloride of zinc.

Drainage of wounds is to be employed only exceptionally, in order not to hinder a possible healing by first intention.

To determine the course of the wound, it appears to be of importance to discover the attitude in which the injury was received, in order the more easily to discover the course of the projectile, by subsequent imitation of this attitude. In the second place, special attention must be directed to the nature of the pieces of garments (or armor) in the neighborhood of the wound of entry, in order to be able to judge beforehand whether any particles of the clothing, etc., and if so, how many and what ones, have been carried into the canal of the wound.

Again, in injuries of this class, even if no fractures are present, we will generally proceed to the application of splints, because this contributes, on the one hand, to secure and firm compression of the parts, on the other hand, to the immobilization of the joints.

In part we can employ ready-made splint apparatus; for example, tin-splints (Volkmann), wire-hose (Mayor, Bonnet, Roser), etc. In great measure we shall be able to readily improvise splints from materials corresponding to those above given; for instance, from wire-sieves, from wood-ware (Gooch, Schnyder, Esmarch), or from zinc-plate (Guillery, Schoen‡), etc. In regard to splints improvised

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* Corresponding somewhat in form and size to the marks of identification as they were used in the American war, and as they are pictured in Gurlt, Abbildungen zur Kraukenpflege in Felde nach besten Hodellen der pariser Austellung rom J., 1867, Taf. XVI., Fig. 10.

† Paul Brüns, Zur Antiseptik. in Kriege. Arch. f. Klin. Chirurgie, 1879. Bd. XXIV., Heft 2, also Deutsche militärärztl. Ztschr., 1879; Heft 12, pp. 609–617, and ditto, 1880, Heft I., p. 42.

‡ Neuber, Ein antiseptischer Danerverband Archiv. f. klin. Chir., 1879. Bd. XXIV., Heft 2, und the same. Ueber den antiseptischen Polsterverband Verhandl. des IX. Congr. d. deutschen Gesellsch. f. Chir.

from branches, bundles of straw, bayonets, scabbards, and guns, compare Esmarch.*

As regards means of transportation from the place of dressing to the field-hospital, or, in case stations for the removal of the sick by rail (by "sanitary trains"), are to be found at not too great a distance, in their transportation home we must employ the same apparatus which we have already learned to use for transportation from the battle-field to the place of dressing. Only now removal by wagons or contrivances of similar nature predominates over removal upon stretchers by hand-bearers.

At the international exhibition of hygiene and life-saving apparatus in Brussels in the year 1876, the ambulance wagons of E. Mayer, in Hanover, met with most general favor.†

But in general, wagons which have been prepared beforehand for the removal of the wounded, whether belonging to the military equipment or to the volunteer sanitary corps, very soon, in the course of great battles, are found to be inadequate. Accordingly, it will be our duty, even in time of peace, to concern ourselves with the adaptation of the ordinary traveling conveyances proper to each country, to the special object of the transportation of the wounded. Every new idea in this department, no matter from what side it may come, will be received the more thankfully, in that it exposes neither the State nor the volunteer sanitary corps to especial expense in time of peace, as has been hitherto very often the case when people allowed themselves to be employed in making very expensive ambulances, which should be as convenient as possible, and specially constructed for containing the greatest possible number of patients. The experiences of the Franco-German war, and of the last Russian campaign, have satisfactorily proved that such ambulances are available only on favorable ground. In the absence of a good road, in swampy

* Weisbach, Deutsche militärärztl. Zeitschrift., 1877; Heft 11.

† Esmarch, Handb. d. Kriegschir. Technik., p. 34.

‡ Catalogue de l'expos. internat., etc. à Bruxelles, 1876; p. 104; and "Specialschrift nebst Abbildungen des Vereins zur Pflege der verwundeten und Krauken Krieger." Hanover. Furthermore: Peltzer, Das Militärsanitätswesen, etc. Berlin, 1877.

§ Riant, Le materiel de secours de la société francaise à l'exposition de 1878.

regions or in mountainous districts, they have proved useless.

We will endeavor, then, to arrange the local means of conveyance (two-wheeled carts, kibitki, wagons arranged with racks, etc.), for the comfortable disposition of the wounded, and this we shall accomplish best by the disposition of the latter upon stretchers. The best example of how this is accomplished is supplied us by the model of the Norwegian peasant-wagon (Smith, *l. c.*), at the Brussels Exhibition of 1876. Another is the contrivance for transportation on two-wheeled carts, from the Paris Exhibition of 1878, which we will find on p. 41 of Riaut's "Report." And still another is the noteworthy summary in regard to the transportation of the wounded by the aid of beasts of burden, contained in circular No. 9 of the American War Department,* issued March 1, 1877.

To the third section of the medical staff is to be assigned another class of injuries, under which are arranged all such as require immediate operative interference, and which we have provided with a blue ticket ("To wait"). Since here we have to do with the performance of major surgical operations, the best operative ability must be brought together in this section.

In the division just described belong:

1. All bleeding wounds. Here the different means for the immediate arrest of hæmorrhage are to be applied, and above all the detection of the bleeding vessel; and for this purpose a free incision of the path of the shot will often be necessary.

2. All injuries of vessels, even when no bleeding occurs, on the spot. In all such cases, central and peripheral ligation is to be performed, with or without excision of the portion of the vessel ruptured or penetrated by the shot.

3 and 4. Shot-wounds of bones and joints, with comminution. These injuries will be treated according to the rules for the antiseptic treatment of complicated fractures, whether we consider, with Volkmann,† the correct proceeding to be extensive incision of the path of the shot, laying bare the seat of fracture, removal of all loose splinters,

* Otis, A report to the Surgeon-general on the transport of sick and wounded by pack animals. Circular No. 9.

† R. Volkmann, Die Behandlung der complicirten Fracturen. Samuel Klin. Vortr. 1877, Nos. 117–118.

thorough disinfection of the wound, etc., or whether in correspondence with the experience of Reyher* and Bergmann† in the Turco-Russian war, we venture the endeavor to obtain a cure, under a rigidly antiseptic protective dressing, without making any attack upon the comminuted fracture itself until the subsequent course of the case shows the impossibility of a cure by antiseptic means.

5. All injuries of the bones of the skull; especially such as penetrate to the brain. Here we shall have to proceed entirely according to the rules given under 3 and 4. Except that here the active mode of procedure (laying bare the site of fracture, extraction of loose splinters, application of chloride of zinc, drainage, Lister dressing) is still more expedient on account of the irritation which the brain suffers through fragments of bone which press upon it. Moreover, Socin,‡ by the procedure here described, has obtained very remarkable results in the analogous injuries sustained during a time of peace (see Lecture XI).

6. Shot wounds of the larynx. For these we have already pronounced the performance of tracheotomy as an act of prophylaxis necessary for every case.

7. Shot-wounds of the lungs, with hæmoptysis. Here it must be left to the judgment in each case by itself, whether in addition to the subcutaneous injection of morphine, venesection should be performed or not (see Lecture VI.)

8. Shot-wounds of the abdomen, with prolapse of the intestines. After cleansing and subsequent suture of the intestine, the latter is to be replaced and a suture applied to the abdominal wall.

9. Shot-wounds of the bladder. If in these it be possible to introduce a catheter, it ought to be left permanently in the bladder to effect a continuous removal of the urine. If the urethra is injured and impassable at the time, an opening into the bladder must be made immediately, and, in addition, external urethrotomy performed, with the introduction of a permanent catheter (see treatment of shot-

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* Reyher, Die antiseptische Wundbehandlung in d. Kriegs. Chirurgie. Samuel Klin. Vorträge, Nos. 142 to 143.

† Bergmann, Die Behandlung der Schusswunden des Kniegelenks im Kriege. Stuttgart, 1878.

‡ Socin, Zur Behandlung der Kopfoerletzungen. Corresponderzblatt f. schweizer terzte, 1876, No. 24.

wounds of the bladder, p. 157 ; and also posterior catheterization, p. 153).

10. Shot-wounds of the testicles. These are among the most painful of gun-shot injuries. They are to be treated together with the administration of morphine, by antiseptic compression and suspension.

11. Shattering of entire extremities. Most frequently occurring from the action of fragments of shells. Here amputation is called for.

The performance of resections at the dressing-station is to be confined within the narrowest limits possible, and to be deferred to the field-hospital. When antisepsis is rigidly carried out, resections can generally be performed as secondary operations.

We turn, finally, to the last class of the wounded (red cards with "To remain" upon them), who, as not capable of transportation, must remain at the dressing-station. Should the wounded of this class survive their injuries, their removal would be ordered when all the other patients had been removed from the dressing-station.

Hereto belong :

1. All who are excessively exsanguinated.
2. All who are unconscious.
3. All head injuries with considerable hernia of the brain or extensive injury to the brain-substance.
4. Injuries of the spinal column and of the pelvis, the latter especially if associated with comminution or extensive solution of continuity.
5. Multiple severe injuries.

The patients here considered, who are to be transferred to section four of the medical staff, need especially careful attention and a continuous intelligent supervision, in order to save what yet is capable of being saved.

More particularly in head-injuries of this class it might be that antisepsis would afford happier results than such as we had the mournful opportunity of witnessing, together with the indescribable distress associated with them, at the dressing-stations in the Franco-German war.

For these patients it is above all things necessary to procure as good and as secure quarters as possible, since, as has already been said, we must delay their removal almost up to the time of the cessation of our activity at the dressing-station; and only in cases where our duty concerns not the victorious but the defeated and retreating army, will

the removal to the rear be accelerated in accordance with the strength of those who are most severely injured.

So you see that the complicated and often excessive labor at the dressing-station can be carried on in the most efficient manner, if in every case of injuries to numbers of men we follow the important principles of division of labor and harmonious coöperation of the working forces.

# INDEX.

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